GRAPHIC PRODUCTION CONTROL

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TO MY FATHER

PREFACE

A PSYCHOLOGIST recently told me that I was a radical. A good friend has been kind enough to credit me with a practical viewpoint. If both are correct in their estimates, then I suppose I must confess to being a "practical radical," and that I am radical in the practice of my profession. I am not so sure of the former, but I will plead guilty as to the latter, for I have always attempted to avoid clinging to the generally accepted, just for the sake of clinging, if a better way could be developed. Most people cling to things because they are afraid to let go, fearful of something with which they are unfamiliar.

Early in my business career, I observed, here, there and elsewhere, arrays of forms, figures and statistics—some simple, others fearfully and wonderfully thrown together; some coördinated, others a hodge-podge. As I studied, I observed further that the intelligent use of forms, figures and statistics *was in direct proportion to the perception of the person using them.* It was only a step to reason out that if perception meant "quick seeing," then the thing to do was to *picture in advance* the results of this perceptiveness, in so far as this was possible, and to apply it to production work in industry, thereby reducing executive fatigue, facilitating quicker and better decisions and speeding up production, all factors in increasing industrial efficiency.

In 1906 or 1907, I do not remember which, I presented a few charts in a series of articles in the pages of *The Engineering Magazine.* In 1908 and 1909, I made use of charts in production work in two plants in Erie and Warren, Pa.

About 1910, in the shops of a midwestern plant, I developed the "anglegraph," shown on page 139 of the author's book "Installing Efficiency Methods," and reproduced in "Planning and Time Studies," by Mr. George S. Armstrong, page 144. This "anglegraph" is illustrated on page 141 of this book.

A few years later, with the assistance of some very capable young men, more active work along lines of graphics in production work was begun in the shops of several representative plants. The excellent coöperation of a number of other men has made it possible to develop the art of graphic presentation in production control, to the extent that has made possible the publication of this book. The result today is that "Graphic Production Control" is being considered more seriously by industrial managers than ever before, justifying the author's slogan—*Let lines replace figures.*

The author's prophecy is that, as in warfare, graphics is the coming mechanism in industry; that because of its comprehensiveness, simplicity, ease of operation and vividness, and its superiority over the non-graphic methods that are in use in so many places, industry cannot get along without it. The popularity of the "moving picture" is largely due to its graphical aspect—a fact all will admit.

The real purpose of this book is to place before industrial executives a complete description of the mechanisms of Graphic Production Control and their application to industrial problems. The idea has been to so thoroughly illustrate the text as to facilitate a proper study of the book. The presentation has been arranged in five parts:

Section I deals with the philosophic aspect of Graphic Production Control, in which attention is called to the need of production in these stirring times, the relation of management to production, the use of graphics in warfare and industry, the ideals and laws of Graphic Production Con-

trol, as well as the fundamental considerations which must be recognized in the installation of this plan.

Section II deals with the preliminary steps in Graphic Production Control, with special reference to the preparations necessary in organizing for graphics, the program of introduction and the analysis of the general situation.

In Section III we have dealt entirely with the practical installation of Graphic Production Control, starting from tentative organization of work and continuing through to auxiliary control mechanisms.

Section IV considers the managerial features of Graphic Production Control, treating the matter of graphic presentation of executive information—Graphic Production Control in its relation to Organization, Standardization and Costs, and the relation of graphics to the Labor problem.

In Section V, the conclusion, consideration has been given to the pitfalls of Graphic Production Control and the economic aspects of graphics in industry.

To indicate the universal applicability of graphic methods in industry, it should be stated that the material in this book is based on experience in the development and use of graphics in the following lines: textile machinery; gas traction engines; gray iron castings; brass castings; steel castings; steel plate construction; metal furniture; automobile axles and transmissions; small motors; taps, dies, reamers and gauges; hardware; clothing; rubber tires and tubes; truck axles; oil producing and refining; fiber board and automobiles.

It seems only fitting, in passing this message to executives, to make mention of those whose efforts have so ably assisted the author. Mr. Walter Glenn Scott, a member of the author's firm, has done more, over a longer period of time, than any other one man in the author's organization, both along lines of research and constructive installation work, and is therefore entitled to special mention. Mr.

A. H. Riehl, who was at one time associated with the author, and Mr. G. Sumner Small, now a member of his firm, are also entitled to credit for their efforts in the early days of the development.

Other men whose names should be mentioned in this connection are Mr. Irving A. Berndt and Mr. Albert McDonald, members of the firm, and Messrs. C. L. Boone, J. M. Coffey, W. P. Hopkins, A. W. Johnson, W. B. Montgomery, B. B. Russell, and E. J. Schultz, of the firm staff. Credit is also due Messrs. W. T. Birdsall, P. A. Jameson, F. G. Riehl, B. L. Van Schaick, and R. A. Wurzburg, who are no longer associated with the author, but whose assistance was none the less helpful. Special mention is made of the aid and constructive help of Mr. J. P. Jordan, a member of the author's firm.

This book, therefore, can well be considered as written by the Knoeppel Organization.

The author also acknowledges his indebtedness to Mr. L. P. Alford, who, as Editor of Industrial Management, was responsible for the publication of the series of articles on "Graphic Production Control" which appeared in the pages of Industrial Management in 1918 and 1919, and around which this book was developed.

C. E. Knoeppel.

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Chapter I

PRODUCTION! THE CRYING NEED OF THE WORLD

1 We have spoken of the world cycles that have passed, as the iron age, the steel age, or the electrical age. Certain it is that we have been passing through an age of *invention;* a period of discovering and harnessing the laws and products of nature. It is equally certain, if we analyze closely enough, that the coming age will be that of securing the fruits of invention, through the rapid and economic making of things,—in other words, *the age of production.*

2 Reconstruction following a period of war forces a development in the realm of production, both intensive and extensive. Then we find a world of depleted treasuries; of ruined and devastated territories; of helpless and poverty-stricken peoples; of crippled, blind and diseased men; of nations hungry for the food necessities of life; of disorganization and confusion carried to the *n*th power.

3 To salvage and reconstruct requires immense quantities of raw and semi-finished materials, machinery and equipment, supplies, building materials, farm products, clothing, ships and many other elements which enter into the economic life of a nation, and which its man-power will have to use wisely and well. After the world has stopped its work of destruction it must turn to the work of production, on a scale even greater than that of the destruction. If it does not, then there will be unnecessary delays, with their resultant by-products—waste, inefficiency, poverty, industrial clash and general suffering.

4 To rebuild a world, for that is what it practically amounts to, demands a universal speeding up of production,

through the use of every possible device that has been or can be developed.

5 Production, Production, PRODUCTION! The crying need of the world in peace as well as in war.

6 Produce, Produce, PRODUCE! This is the command all of us must obey.

7 Problems of distribution? They are insignificant in comparison to those of getting and keeping the world on a producing basis.

8 To Speed Production it Must First Be Controlled. It therefore follows that the thing most needed in any reconstruction period is the most efficient means for controlling production.

9 What will furnish this means?

10 A type of management which can be characterized as "graphical management," in which use is made of *graphics* in controlling production, and through which we indirectly secure *organization, standardization and costs.*

11 We recognize in our American life that the foremost fundamental is publicity. It possesses the valuable characteristic of enabling our people to establish a proper relationship of things. We acquire periodic rottenness in spots. Publicity brings it to the surface. We know how to apply the remedies.

12 In industry we are rapidly eliminating generalizations and are becoming more and more specific. War taught us the proper realization of essentials. We realize as never before that we have no time for dreams, imaginings, excuses, mere talk. Facts, results, direct drives are the only things which will meet the demands of the present and the future. We are eliminating that popular American game—"passing the buck." In fact, our hands are full, and they will remain so for many years to come. Each one must assume his full share of the responsibility, and if he does not, we must have a means of knowing it and why.

13 Industry realizes, as a result of the stress of war, that its machinery of management was inadequate to meet the demands. It was strenuous, wasteful, inefficient. There was infinite detail without proper coördination. It did not know what steps to take to eliminate the troubles, therefore

they accumulated. Methods of control did not supply a sufficient degree of easily understood publicity to allow for systematic and anticipative initiative.

14 Careful study of the reasons for this, reveals the following:

A Systems and methods so unwieldy as to fail to measure up to the expectations.

B Inability to secure an organization of the caliber and vision required to operate the plans set forth.

C Inflexibility of methods, requiring at the start a high degree of organization and development of standards, before they could be applied with any degree of success.

D Inability of managements to carry out what they knew was right.

E Inability of methods to keep pace with the changes in modern conditions.

F Methods of such a nature as to result in scattered rather than coördinated effect and action.

G Methods not sufficiently anticipative in their characteristics to eliminate or lessen the troubles about to occur.

15 In general, the average organization for production control, even where it is well thought out and coördinated, loses much of the effectiveness and timeliness in the manipulation of correctives, as well as the psychological effect, on both workmen and executives, of means which can be strikingly anticipative in nature.

16 Of late years a few of the more progressive managers and production engineers, realizing the deficiencies of existing methods of shop control, have sought to evolve something better and have turned to graphical presentation of facts and relationships. They have sought to visualize and to facilitate as much as possible the mental processes in connection with plant control. If we carefully analyze why graphical methods have been adopted in industry, we begin to wonder why they have not been used before, as we find the evolution to graphics to be of a startling character.

17 We find the engineer deals with factors of stress and

strain, in the design of his product, in terms of graphics. The mechanic of more than average ability so organizes his thought that he builds and constructs by being able to analyze correctly and apply all the practices of the past, in a graphical way. In mathematical deductions, both engineer and mechanic depend on and are fortified with:

A Judgment by eye.

B Numerical mathematics—that is, arithmetic and algebra.

C Analytical mathematics—that is, geometry, trigonometry, analytical geometry and differential and integral calculus, which were productive of such assistance as the triangle of forces, the funicular polygon, the distortion diagram, the graphical solution for section moduli and moments of inertia, and such devices as the planimeter, slide rule, log paper and the theory of alignment charts.

18 After the engineer or mechanic has developed his machine or structure, he must have some means of conveying the results of his studies to bodies of workmen and foremen, who are responsible for manufacture. Each man must in some way be made to conceive what form, shape and dimensions, and the relation of parts, go with the thing he is to produce. We find here an evolution to the graphic, in conveying this knowledge, as follows:

A Spoken and written words, giving mental pictures.

B Models, for comparison.

C Pictorial sketches.

D Modern mechanical drawings, incorporating many conventional representations, such that absolute relationships are shown.

19 From another angle, the evolution to graphics is as follows:

A The accountant, realizing his difficulty in getting his employer to understand relationships, in his analysis of financial and cost conditions, has supplemented his mass of figures by simple and compound graphical charts, with the result that he has been able to secure the attention of his superiors to a much greater extent.

B Sales managers have for some little time been making use of maps in combination with colored and numbered pins, enabling them to get a bird's-eye view of present and future conditions, which makes it easier to plan out campaigns than would be the case by studying a mass of dry figures.

C Railroads have recognized the advantages and greater freedom from human error, in the control of traffic conditions, through graphic visualization. This is evidenced not only in the miniature railroad systems, where signal pins, pegs, or runners give the schedule, location and progress of traffic, but also in the actual mechanisms used in signaling trains.

D Our modern armies, to a greater extent than is generally thought possible, are controlled through the medium of charts, boards, pins, colors and other graphic devices.

E Our technical papers are more and more making use of graphical presentation to illustrate the important points of their articles.

F Illustrations in books are but another way of presenting facts graphically.

G The advertising manager uses graphics to advantage, in bringing to the attention of the public, quality and quantity relationships, in the products he is desirous of selling.

H Market letters in financial circles are more and more making use of charts to show tendencies of stocks, bonds and commodity prices.

I As all are aware, statistical publications, in order to be of real service, must show charts so as to make relationships easily noticeable and interesting.

J The clock face, the sun dial, the gauge glass, the compass, the watchman's clock strip, the theater diagram, the thermometer, and other mechanisms of like nature, are forms of graphical presentation which we would not for a moment think of dispensing with.

20 The reason for the above is that the average person does not possess a synthetic mind or keenly perceptive in-

tellect. Most minds are of the reflective or analytical type. It is difficult for most people to take a mass of unrelated facts and figures and see them in an orderly, related and coördinated whole. Few minds can visualize entireties or things in mass formation. They reason from parts and elements rather than perceiving the whole. The "mind's eye" in most people is far from developed, and as a result we find few people who are highly imaginative in a practical sense or who can visualize from disassociated facts and figures.

21 Even those possessing unusual powers of perceptiveness and synthesis, are often handicapped in getting broad viewpoints, unless assisted by means which relieve the mind from the burden of intense concentration and long periods of application. Graphic presentation enables the mind to grasp details quickly and puts things on a semi-routine basis. This speeds up the mental processes and reduces to a minimum mental fatigue, so common in our executives.

22 Imagine, if you will, attempting to teach a child music through written descriptions of scales and notes, instead of the graphical methods we all know so well. Try describing to your friend some rare painting, through the use of words, and see how quickly you will bore him. Show him the painting and he will rave over it. The beauties of nature must be seen; they cannot be described by words alone.

23 What do we mean by graphics?

24 Of the five senses—sight, hearing, smell, taste and touch—there is only one that is most used, in so far as production in industry is concerned,—*sight*. In planning, controlling and getting out production, we do not use the senses of smell or taste at all. Hearing is employed to some extent, as is touch; but their employment is of minor importance. The organ most used is the eye, the camera of the mind, which, photographing all things within its vision, gives the brain, or executive of the body, the basis for reasoning, formulating decisions and initiating action. In other words, the chain is—eye, to brain, to action.

25 Consequently anything which facilitates the work of the eye is worthy of consideration and adoption. The painting of the artist portrays the beauties of nature *for our*

eyes. Would we do without the artist? The camera reproduces details, scenes and views that are worthy our attention *for our eyes to see.* Would we do without the camera?

26 Graphical presentation in industry pictures the essential happenings of the shop *for our eyes,* and is to production what the artist and the camera are to us in other things. Can we do without graphics in the shop if this comparison holds?

27 We are engaged in a "war after the war,"—not military in character, to be sure, but a form of warfare nevertheless. Commercial clash between nations, between industries and between concerns in the same industry; class strife; revolutions in ideas and ideals; the race between the high cost of living and the cost of living high; the sparring between capital and labor, all point to but one thing —a kind of warfare which can be called social, economic, industrial or by any other name you choose, but a warfare which will be won only by that nation giving due consideration to the proper coördination of the elements involved. The trade of the world will go to that nation which is the most prosperous. *That nation which is most efficient will be the most prosperous.*

28 The best coördination is that which is based on the principle of visualization, hence the author's plea for a graphic control of production in industry, since industry is going to be so important a factor in the new warfare ahead of us, with production efficiency a prime requirement.

29 As previously stated, the coming era can well be termed *the age of production.* Destruction such as went on for five years, can spell nothing else than an extensive and intensive production of materials and supplies, food, clothing, machinery and other commodities. *In other words, we must have quantity production. If quantity production was necessary to win the war, it is doubly necessary in the years following the war.*

Chapter II

MANAGEMENT IN ITS RELATION TO PRODUCTION

30 We have seen from the previous chapter that the need of the world is Production, and that Graphic Production Control is the real mechanism necessary to secure it efficiently and economically.

31 These questions arise: In whose hands? Whose responsibility? Where will the initiative come from?

32 The answer is—*management.*

33 At no time in the history of our country has management been so necessary or so essential in industry as at present. We are in an era, the like of which we never experienced before and will probably never experience again. President Wilson eloquently expressed the thought in mind when he stated that the world was on an "operating table." New problems, new conditions, new theories confront us, and only the ablest leadership and guidance will pilot us safely through the uncertainties which are a part of our present-day life.

34 This leadership must be furnished by *management.*

35 In 1916, in "Industrial Preparedness," the author stated: "The European War will end—when, we know not, but end it will—and when the end comes we are bound to be confronted with problems of adjustment—problems which should be receiving attention *now,* not after the war is over.

36 "We in America must recognize these definite facts—first, when the warring nations lay down their arms after peace is declared, there will be a mobilization of money, men, materials and machinery, and an economic or commer-

cial war will begin. The nations at war are even now getting ready for it. Second, there will be a gigantic awakening in Europe when the fifteen to twenty million serious-minded, bitter and determined men in the trenches, who have been through all the horrors of hell, return to civil and industrial life, with new conceptions, gained through daily contact with organization, control and discipline.

37 "Think as you will, a careful study of the subject, the consensus of opinion of the great thinkers of the country and an analysis of the foregoing, all point to but one thing —*we must put our house in order.*"

38 In doing this we must rely on *Management.*

39 What is meant by Management?

40 The author's definition is—*Efficient management is the wise use of coördinated knowledge.* The unwise use of coördinated knowledge, or the wise use of knowledge not coördinated, can therefore only mean inefficient management.

41 To explain the above more thoroughly, let us get away from Industry for a moment and turn to the Great War. We are all familiar with the mistakes the Allies made during the early period of the war and the success of the Germans. Each allied country had its generals, competent and experienced, and yet they did not seem able to make the gains they really counted on. The reason why they were not more successful was that they were making *wise* use of knowledge *not* coördinated. As soon as the allied leadership was placed under Foch and coördinated knowledge was made use of, the Allies became much more successful and finally won the war. The defeat of the Germans might have been due to inferior economic resources and forces, or to the fact that they were making *unwise* use of coördinated knowledge.

42 Therefore, coördinated knowledge is the basis of Management, through the wise use of which, we secure efficiency in attainment.

43 Still using warfare as our guide, General de Peucker said: "When a soldier knows that he knows, when he feels that what he has learned will enable him to steer easily through difficult circumstances, his character is strength-

ened. He acquires the ability to make wise decisions and to put them into practice efficiently.''

44 Two things now appear as necessary in the use of our coördinated knowledge:

A Objective.
B Expert Advice.

45 As regards the former, Foch, in his book ''The Principles of War,'' says: ''In war everything is correlated. Every move has some reason, seeks some object; once that object is determined, it decides the nature and importance of the means to be employed.'' With reference to the latter, Von der Goltz said: ''To-day the general-in-chief can no longer direct everything. Even a genius requires a staff of helpers, filled with initiative and thoroughly trained. How much more will a general not of unusual merit need to be assisted. The command of an army is too complex for a single man—at the same time, certain technical questions require special knowledge.''

46 In other words, the elements in efficient management are:

A Know, and know that you know.
B Have an objective based on that knowledge.
C Seek expert advice and aid in coördination.

47 In this connection Von Moltke makes this statement: ''A general therefore, who, in every specific case makes, if not the best disposition, at least efficient disposition, has always a prospect of attaining his objective.''

48 Here is another thought of importance: Foch says, in speaking of teaching warfare: ''As a matter of fact, there is no studying on the battle-field. It is then simply a case of doing what is possible to make use of what one *knows,* and in order to make a little *possible,* one must know *much.''* And then, in showing that warfare can be taught, he says: ''This education sprung from the teachings of history, and has resulted in a *theory* of war which can be taught and which will be taught further, and in a *doctrine* which can be practiced.''

49 To make efficient dispositions, to use wisely coördi-

nated knowledge, and to manage well, an executive must not only *know,*—he must know *much;* he must learn the *theory* of management from all the accumulated information possible, and having a *doctrine,* must practice it, based on an *objective,* with *staff advice* keeping him from unwise use of the knowledge available.

50 This not only describes the management of the future, but pictures the type of executive on whom will rest the great responsibility placed upon his shoulders by the problems of the day.

51 It is in connection with the above that Graphic Production Control enters in to coördinate the elements of Production and Management. It can well be termed the bridge between the two. We need Production—our objective. Management is the machinery, and Graphics, the motive power.

52 The executive must make efficient, if not the best dispositions. From what? Coördinated knowledge.

53 He must not only know, but must know *much.* From where? Coördinated knowledge.

54 He must have a *theory* of management. Where will he learn it? From coördinated knowledge.

55 He must practice the *doctrine* he has learned. How will he do it? Through coördinated knowledge. Graphic Production Control is nothing at all if not coördinated knowledge. It has a well defined and practical theory—that of showing facts in such a manner that related parts are visualized. It has a well defined doctrine or practice which enables one not only to know, but to know *much,* thereby making efficient dispositions.

56 Consequently, this becomes our definition—*Efficient management is the wise and proper use of all coördinated knowledge, graphically displayed.*

57 Take the "moving picture" as an illustration. Not a word is spoken during a performance; only at intervals are descriptive or spoken words thrown on the screen. Yet consider the hold on the public. Why? *Because the moving picture coördinates graphically.*

58 What do we aim to do in Management? What is its objective? To make wise decisions, and put them into prac-

tice, both promptly and efficiently. General de Peucker stated that when a soldier knows that he knows, when he feels that what he has learned will enable him to steer easily through difficult circumstances, he will do these things. Is an executive any different from a soldier in this respect?

59 Therefore, any means whereby the Management can decide wisely and execute promptly and efficiently, is an essential in Industry—no, a positive necessity.

60 Take a record showing relativeness or comparisons, progress or results, exceptions or differences, covering related factors, and put them all in plain sight so that the perception comprehends the entirety at a glance, and is not the making of dispositions facilitated?

61 If a record is highly anticipative in character and graphically presented, have not we a "forewarned is forearmed" proposition?

62 If coördinated knowledge is the basis of Management and we can show this knowledge relatively and progressively through graphics, are we not assisting in making wise decisions and executing promptly?

63 It therefore seems as if Graphic Production Control is a factor of more than ordinary importance in securing the production of all things the world is so hungry for. Certain it is, we will not produce efficiently without wise management, and we cannot have wise management if it decides unwisely and executes inefficiently. It must use something as its basis. This basis is knowledge. It cannot reason properly from detached elements, or related factors considered separately. Hence, it must use coördinated knowledge. The problem then is to determine the means of portraying this coördinated knowledge.

64 Will it be figures, dry and uninteresting, or vast arrays of forms, complicated and difficult to coördinate, or compilations of statistics which must be studied hard to comprehend? Or will it be graphic presentation, so that, paralleling the observation of time, we look at the watch and at a glance note the time, instead of receiving a card saying "23 minutes past 7"?

65 If Management is wise it will use that mechanism which will facilitate its use of coördinated knowledge, and

this will be Graphic Production Control, as it will be found to measure up to the requirements of not only *knowing,* but *knowing much.*

66 So far we have confined our discussion to the relation of management to production. It has another and perhaps greater relation, and that is its relation to Capital and Labor, and it is here that management must recognize its great obligation.

67 We are in the midst of clash and industrial unrest. Labor "is in the saddle," and through strikes is forcing conditions that can only mean trouble for all of us. It takes the position that because labor is the basis of industry, labor is everything and must therefore dictate and dominate the situation. If it wants a 50% increase in wages, it strikes for it; if it wants a 40-hour week, it strikes for it; and when we observe strikes among policemen, firemen, actors and even grave-diggers, there is no mistaking the tendency. Labor knows only its own side and seems not to care for the other sides, on the assumption perhaps that there are no other sides.

68 Capital, on the other hand, has been guilty of economic crimes in charging exorbitant prices; in unfairness; in making the public pay for idleness; in profiteering. It has, like labor, seen only its own side, feeling that because money supplied the sinews of business, money was everything and labor only a commodity to be purchased in the cheapest markets. Both have been wrong. Both are wrong now. Both being wrong makes it all the worse for the "dear public" of which all of us are a part. Labor is like the frog which, making one jump forward, takes two backward. Capital has repeatedly killed the goose which laid the golden egg.

69 Will capital find the solution of our industrial problems? No. Will labor? No. Why? Because neither side knows that of the other, nor trusts the other sufficiently. Any suggestion on the part of either would be viewed with suspicion by the other.

70 The answer? *Management.*

71 Management, using money and time to produce commodities, stands between capital on the one hand and labor on the other. It knows *both* sides because it deals directly

with both. It knows what capital should do for labor and what labor should do for capital, *because it is constantly coördinating their forces.*

72 Management, making wise use of coördinated knowledge, must rise in its might and dominate the situation, as no other force in our commercial life is in a position to do so.

73 The strike and the lockout are wasteful and inefficient. This waste and inefficiency we could stand, if we had to, provided they were constructive forces which brought us closer to lower prices, to industrial democracy, to better conditions of living. They do not and never will, are destructive in their effect and *must go.*

74 Without management, capital would make a sorry mess of things because the mere investing of dollars is a long way from making them productive; from converting dollars into shoes, machines and food. Without management, labor would find it equally difficult to manufacture commodities, as considerably more is necessary than the mere doing of work.

75 How would Capital and Labor, without Management, coördinate time and money to the end that products could be manufactured; supply the plans, conceptions and ideas; formulate, decide and execute with courage and vision; carry on the thousand and one things in connection with taking money supplied by capital and through *time* furnished by labor, turn out the products of industry?

76 The trouble is that we have not heard from management to the extent possible. It is unorganized and disorganized. Made up as it is of the great salaried class, and the men in the professions, it has yet to coördinate its ideas, organize its thought, realize its possibilities, and take its rightful place as the real leader in industry.

77 If labor as well as capital could see its successes, failures, accomplishments, shortcomings, difficulties, problems, wastes and inefficiencies, in their relation *to those of the other,* and so arranged graphically that coördination was not a difficult task, would there be this constant clash and industrial unrest? *A thousand times No!* Neither side knows how to work with the other to-day, because neither

side knows the real facts about the other, nor is there a way provided for them to-day to do this.

78 It is here that management must step in, for it is management which knows the facts about each side, as well as the facts about each *with reference to the other.* It is Management working with Capital and Management working with Labor, that enables it to coördinate, to manage, and it is to this force we must look for our leadership in solving our complex industrial problems.

79 If management could graphically portray the conditions as to capital and labor, in a single plant, as regards what they are doing, what they could do, what they are not doing, and carry this to all plants in an industry and to all industries, would it take long for the three to get together? Cannot you see management pointing out to labor the real facts about capital, and to capital what it has heretofore not known about labor, and *telling them both what each should do for the other?*

80 If two warring nations need the friendly offices of a third to effect a truce and work out peace terms, it is certain that warring classes are in need of the same aid.

81 Observe now that our definition of management takes on an added significance as it relates to capital and labor —*Management is the wise use of coördinated knowledge, graphically displayed.*

82 Labor needs to know more about capital in order to know capital better. Capital needs to know more about labor, to know labor better. In this management can help to decided advantage as it is now working *with* both. In the hands of management, graphical presentation can be a pronounced aid, in enabling it not only to use coördinated knowledge wisely, but to be the real coördinator between capital and labor, that production may be secured both economically and in volume.

Chapter III

GRAPHIC CONTROL IN WARFARE

83 Could the American Army in France have been a factor in the winning of the war, if it had been inefficient when in action? Supposing that when ready to fire artillery, there had been no shells; that when the boys were ready to eat, there had been no food; that when ready to fire machine guns, there had been no bullets; that tanks had to stand idle because there were no soldiers to man them; that roads and tracks had not been kept in proper repair; that bridges were down at a time an advance was ordered; that when ready to fire at the enemy, the men had to wait on the supply stations for their rifles. Would we have gone very far? What then was the reason for the brilliant record "our boys" made in the closing days of the conflict?

84 Proper Coördination of a Graphic Nature. In support of this contention let me present a few extracts from an article "S. O. S.," by Mr. Isaac F. Marcosson, in the November 30, 1918, issue of *The Saturday Evening Post.*

> "Let us now sit in with the general staff at its daily morning meeting. You will get such a demonstration of teamwork as to make you sit up. The walls of the office of the chief of staff—like those of the commanding general—reflect the spirit of our organization and the way it is swung. First of all you see the great supply map of France criss-crossed with our lines of communication. At first glance you may think this is a picture puzzle, but on closer investigation you see that these winding and colored avenues are studded with symbols. You see stars in circles, ships, tents, crosses,

coffee pots, buildings. You are not long in finding out what they mean. At the lower left-hand corner is a key to the puzzle. Each symbol has a meaning all its own. The star in a circle indicates the general headquarters; the ship shows the location of a port that we use; the tent is the site of our instruction camp; the black cross reveals a base hospital; the white cross, a rest station; the coffee pot, a coffee station for traveling troops; the engine, a locomotive repair shop; the freight car, a car-erection site; the bumper, a railway-regulation yard; an ax, a forestry camp; the propeller, an aviation camp; the bursting shell, an ammunition depot; a black naval pennant, a section headquarters, and so on. In other words, you can look at this map and see at a glance the scope and extent of all your activities in France and what and where they are.

"On the walls are also square yards of charts and diagrams, for this is a war of organization all put down in specifications and blueprints long before a wheel is turned or a shot fired. It is one of the many sheets that Mars has taken from the book of big business. I have seen square miles of army diagrams in this war, but I have never seen any that were more concrete or comprehensive than those used by Services of Supply. Every service has its master chart; every subordinate section has its own little sheet. Put three men together in an army office in France, and the first thing they do is to create a little chart of their organization. Nor is it a wasted effort. A great master of American industry once said, 'Teach with the eye,' so he put signs all over the factory. The man who knows just what he has to do and where he belongs seldom makes mistakes. Hence the value of charts in the business of war.

"The walls of the tonnage room tell the story. They are hung with charts of tonnage progress. You can stand in the center of this room and see in colored lines, figures and diagrams that a child can understand, just what is going on in every port. There is a chart for every port in France. Up and down one side of the chart is a list of individual cargo items to be unloaded,

such as lumber, coal, forage, railway supplies, foodstuffs, clothing, quartermaster's supplies and construction material. A black line radiating from each item means its receipt; a red line indicates the progress of the evacuation of those receipts. If the black line is longer than the red it shows that cargo is piling up at the ports. If these lines are of the same length all is well and the stuff is moving out, which means no congestion.

"These lines are marked off in days and weeks. This is what might be called the tonnage-movement chart. Then there is a chart that shows the work of all ports in items, days, weeks and months. From this you can see almost in a second where labor is doing its full job or where it is falling down.

"The same system is used to show the work of troop transports. On a huge chart you see the name of the ship, the length of time in a French port indicated in black; the time on the ocean in red, and its stay in the American port in green. From this chart you can tell that the average turn around of some troop transports has dropped from sixty-eight to thirty-five days. A similar system shows how the turn around of cargo ships has been reduced from ninety-one days to seventy-one days, while the round trip of arrival transports has decreased from eighty-four to sixty days."

85 As another excellent example of graphic control in warfare, the following is worth reading:

"How General Joffre Runs His Army

"Dunkirk, October 28 (by mail).—A man in pajamas (at least he wears them most of the time, being too busy to dress) is running the 1001 details of the French army. General Joffre is at the head and he handles the big questions, presses the buttons, so to speak, but General Bertholet, Chief of Staff, does the actual work.

"After several trips along the fringe of the war, after meeting thousands of soldiers on the same day, some going north, some going south, in what appeared

to be a hopeless tangle, it struck me more forcibly than ever that the modern fighting machine is the most complicated thing on earth.

"I tried to imagine myself commanding all this, to grasp how a 200-mile line of this sort could be controlled and how it could possibly be kept from getting tangled up with itself and without interference by an enemy. My curiosity grew, until I decided to find out how all this business is managed by one man.

"In General Joffre's headquarters, in a certain long room, hangs a special map, the scale of which is $\frac{1}{1000}$. It shows every road, canal, railway, bridle path, pig trail, bridge, clump of trees, hill, mountain, valley, river, creek, rill and swamp. This is part of the outfit. Another part is a wonderful collection of wax-headed pins of all colors and sizes. These represent army units of all sizes and all organizations. Into the long room run many wires, both telephone and telegraph. Wireless apparatus is also in this room. The way it works seems wonderfully simple when it is explained.

"The battle is about to commence. The troops have been distributed all along the 200-mile line. The Germans are facing them. A bell rings: 'Hello! Yes! The Germans are attacking General Durand's division? They are in superior number? The general needs reinforcements? All right.'

"The staff officer who has taken this information over the 'phone hurries to where General Bertholet is sleeping. The general has just dozed off. This is the first sleep he has had in thirty-six hours, but General Bertholet is wide awake in an instant. He jumps to the floor, still wearing his pajamas, the only garment he has worn in several days. The staff officer reports.

"In a twinkle, General Bertholet, who knows his map as he does his own face, locates Durand's division. He knows that ten miles back of Durand's command are quartered a number of reserves, under General Blanc, according to the pins. General Bertholet also learns from the pins that a number of autobuses are near General Blanc's soldiers.

" 'Order General Blanc,' he commands, 'to reinforce Durand at once with 10,000 men, four batteries of 75-millimeter artillery, ten machine guns and three squadrons of cavalry. Tell Blanc to transport his troops in autobuses.'

"Within two minutes General Blanc has received the order. Within five more he is executing it, and General Durand is informed that help is coming to him.

"Then General Bertholet takes another nap, if the battle will permit. If it does not, he stays awake to direct men who are miles away from him.

"Every time a bridge is blown up or a pontoon has been thrown across a stream or a food convoy shifts, General Bertholet gets up and shifts his pins to indicate the change. Nothing happens along the 200-mile battle line but that General Bertholet, still in pajamas, leaps from his bed and changes the pins on the map. The map must be kept up to the minute. General Joffre must be able to look at it any time of the day or night.

"As far as possible, through information brought in by spies or aviators, the forces of the enemy are kept track of in the same manner. No detail that is of use is overlooked. The pins indicate even the size of the guns, the kind of ammunition they use, and so on *ad infinitum.*"

86 If a war of such gigantic proportions was conducted along such scientific lines; if something so full of the unforeseen was controlled in the way outlined, *what is there to prevent the development of such methods as will give the industrial world the same efficient control of production?*

Chapter IV

GRAPHIC CONTROL IN INDUSTRY

87 There can be no quantity production without production control, and efficient control of production is out of the question unless graphics is used in some form or other. Imagine attempting to describe by words and figures, the work necessary to machine a complicated casting, instead of putting it in the form of a working drawing or blue-printed picture, which the shop man can read to much better advantage!

88 There is another point to consider. In most plants an order taken at a close margin is watched, coaxed and nursed along in the shop, with the result that a profit is made or the loss kept to small proportions. Because attention is forced by financial necessity to what must be done, close supervision sees that it is done. *Why not follow the same procedure as to all orders?*

89 In other words, an order received for entry is something on which a profit will be made or a loss sustained,— one of the two. *There is no middle ground.* Therefore, the time to see to it that a profit will be forthcoming or the loss kept to a minimum, upon completion of the work, is certainly not when the order is partially or entirely completed, *but before it is sent to the plant for starting.*

90 Hence three things are necessary:

A Analysis. The determination of what is to be done, the manner of doing, by whom it should be done, and what it should cost in time and money—the ideal to work to.

B Planning. Coördinating the analyzed information to determine a practical standard.

C Control. The means provided for enabling the shops

to so execute as to either measure up to the standard determined upon, or to anticipate, note and investigate variations in such a way as will result in a constructive attempt subsequently to attain it.

91 With *Analysis, Planning* and *Control* utilized to the fullest, and with *graphics* adopted as the means for portraying the details in connection with the work to be done, the manufacturing world can be assured that it will secure maximum operating efficiency, as "graphic production control" not only controls production, but leads indirectly to better organization, standardization, and costs.

92 What is a graphical presentation?

93 Suppose in a shop we want 100 pieces of something, have received 60, machined 50 and assembled 20. Which of

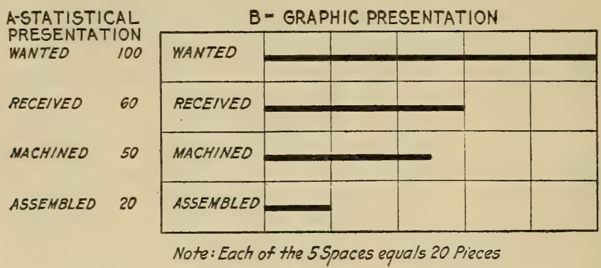


FIGURE 1. COMPARISON OF STATISTICAL AND GRAPHIC PRESENTATIONS

the presentations in Figure 1 is the clearer from the standpoint of a quick, comparative picture?

94 The usual factory production system is a more or less vast array of forms, figures, compilations and statistical statements, which the foremen, department managers or executives must take, compare, analyze and then mentally visualize, before coming to a conclusion. The aim of graphics is to take the essentials and so picture them as both to stimulate and render less of a task the mental processes necessary for forming conclusions.

95 In other words, the purpose of graphics in controlling production, is to picture the elements of shop operations, so as to consider relativeness (or comparisons), progress (or results) and exceptions (or differences), as an

aid in quickly forming conclusions and making decisions that will govern actions looking toward efficient results. As a practical example, note Figure 2 herewith.

96 The outstanding features in favor of graphics, as against the usual methods of controlling shop production, are:

A Simplicity, in that a graphic presentation can be readily understood and read by the average shop man, where a mass of figures becomes indigestible. A graphic

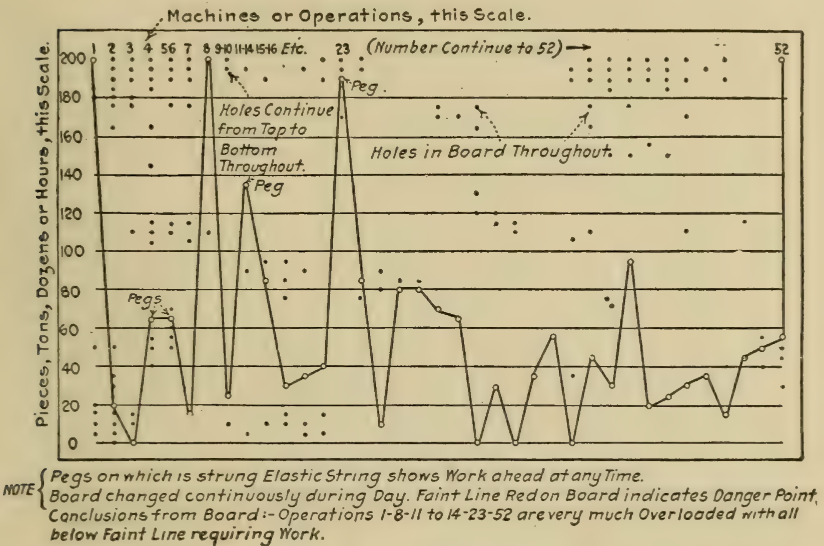


Figure 2. Graphic Record of Progress of Operations

board to a shop man is the same as a trading board to a broker.

B Comprehensiveness, in that all the essentials pertaining to a department or product, are concentrated in a small space, enabling the eye to contemplate an entirety rather than a series of details. A graphic board or chart is the shop or department in miniature.

C Ease of Operation, in that clerical help can easily maintain the graphical methods, leaving the executives free simply to "look and reason."

D Vividness, in that the exceptions stand out in such a

manner as to become much more impressive than an assortment of figures which must be mentally compared and related.

97 In the first place, while designed to indicate *progress* or what is actually happening, it should show *anticipations* or the things that may happen. Let us, therefore, consider the fundamentals in manufacturing in an effort to determine some of the things that graphics consider:

A Detailed plans and instructions.
B Raw materials.
C Labor.
D Equipment and tools.
E Supplies.
F Assembling of parts.
G Supervision.
H Movement of material.

98 Lacking any one or more of these things, delay or congestion occurs. Let us consider possible reasons:

A Lacking Detailed Plans and Instructions may mean that there is no order; that the order is incomplete as to identifying the product to be made; that the order requires modification with insufficient explanation as to changes; doubt as to proper quantity to run through; lack of proper blueprints, sketches or dimensional details; absence of instructions as to auxiliary tools required.

B Lack of Raw Material may mean insufficient quantity; unsuitable quantity; inability to use material on hand because specified for other use; eleventh-hour lack of material believed to be in stock; material which under normal conditions would have been received in time but delayed because of production or transportation troubles; error in quantity available according to inventory.

C Lack of Labor may mean temporary absence of the workman and inability to get substitutes; emergency absence through accident or sickness; voluntary absence as result of labor troubles; absence due to dissipation; inability to get the right kind of labor for the work in hand; inability to get labor owing to the plant growing faster than labor can be secured and trained; general labor shortage.

D Lack of Equipment and Tools may mean scarcity due to breakage; scarcity due to insufficient supply in stock; inability to provide necessary tools due to failure to anticipate peculiar requirements of the job; congestion at machines due to previous breakdown and consequent delay; congestion due to unnecessary use of desired equipment or tools, for products or operations which could have been handled on other equipment not now engaged; failure to make repairs promptly—and to anticipate same.

E Lack of Supplies may mean that material is out of stock; wrong kind of stock; inability to purchase the desired kind at the right moment; error in quantity on inventory; insufficient storage space.

F Lack of Assembly Work may mean failure of stores department or preceding department to deliver material which was available; failure of foreman to assign workmen to the task; failure to secure the necessary supplies; failure to deliver instructions in advance of receipt of material.

G Lack of Supervision may mean too much clerical work by foremen; failure to appoint necessary subforemen; foremen's inability to watch current conditions because too much occupied in training new help or doing inspection work.

H Lack of Proper Material Movement may mean lack of move orders; congestion of material due to carelessness; lack of help; waiting for inspection; lack of facilities.

99 Criticism without the suggestion of an improvement avails little. It is, therefore, necessary in studying production methods to distinguish between the virtues of the plant policies and methods and the merits due the workers' skill, experience and effort. So also must faults and oversights of the management be distinguished from the blunders and carelessness of the workmen. Faults and blunders in total are equal to those of the management plus those of the workmen. If, then, facts as to priority, sequence, delays, errors, blunders, carelessness, oversights, can be made to appear in plain sight for the benefit of all concerned, by means of graphical control, we have a better means of showing this information concurrently than any other so far furnished, and one absolutely impartial and unbiased when it comes

to a consideration of the merits of management and men. "Graphic production control" tells:

A As to the Order. What priority, if any, over its regular sequence? What standard or special order as to design, workmanship, material, ultimate purpose?

B As to the Product. Are designs and full instructions ready? Are all necessary materials in stock and ready? Has time of specific equipment been provided? Are all necessary tools known to be on hand and in good order? Is available labor ready and properly trained?

C As to Progress. Were all preceding operations finished on scheduled time? Will any preceding delay prevent starting current operations on scheduled time? Have recent operations of the sort been running under or beyond scheduled time?

D As to Delays. How are they caused—through insufficient instructions? lack of material or supplies? absence or slowness of worker? lack of tools? non-delivery of parts from preceding department? breakdown of equipment? error in processing by preceding department?

100 The commonest excuse met with in industry is, "I didn't know it in time." Machines may be out of repair, but why are they not kept in repair? Machines may be waiting for work, but why have not proper arrangements been made to keep jobs ahead for them? Operators may not be attending to machines properly, but where is the supervision? Machines may be waiting for set-up men, but why has not this been arranged for in advance? Machines may be waiting for tools, but why are not the tools on hand and in readiness for use? Machines may be waiting for material, but why have not the material requirements been anticipated? The reason these things happen, is because the facts are not made known soon enough to forestall trouble. If a man could be a mind-reader and gifted with a sixth sense or second sight, these things would be anticipated and provision made for efficient running; but, not possessing these gifts, he has to resort to "I didn't know," which is usually true enough, but not the real reason. "Graphic production control" eliminates this excuse be-

cause it portrays *what is going to happen,* as well as what is happening. An average foreman, knowing, hours in advance, that a machine is going to be down for work, or that tools will be needed, or that material will be needed, or that material will have to be moved to the next operation, will see to it that action is secured, which will result in uninterrupted operation. *Graphic methods show these essential requirements well in advance.*

101 No general or introductory treatment of "graphic production control" would be complete without furnishing an outline of what the plan could be expected to show in the way of valuable information for the shop man to use in his work of getting out production. The following is submitted as an example of what a graphic method would indicate:

Relative importance of the various parts of an order from the standpoint of purchasing, processing and assembly.

Pieces received from the outside or from the foundry; pieces processed according to part or operation and the units assembled, at any given time.

Estimated times of the various operations; actual times against estimates (progressive) and the gains or losses in actual times over estimated times.

The costs of operations, as the work progresses.

Relation at any time between the actual progress of an order, in whole or in part, and the normal progress, indicating how far the actual progress is ahead or behind the normal progress.

Apportioning work to be done against equipment, workmen or departments, in such a way as to show congestion or excess capacity.

Performances of machines or operations against estimated productions, showing gains or losses.

Following up purchases.

Continuous inventory of material.

Inventory of labor, in hours, against machines and operations.

Manufacturing schedules showing dates work should start and finish, with provision for showing progress.

Schedules for purchasing department, pattern shop, foundry and tool room.

How much work is ahead of any machine.

How much material is actually at any machine.

Sequence of jobs.

What job is on machine, and, if there are others, the order of their importance.

What orders on any particular machine are held up for tools.

When tools are received.

When it is necessary to get more material to prevent breaking down a machine for a different job.

When material has arrived.

When it is necessary to get more orders to keep certain machines busy.

What machines are idle and for how long.

Whether machines are idle for: Breakdown, absent workman, workman on more important work, no work, waiting for tools or drawings, waiting for inspection, setting up, no power, waiting for crane.

When machine starts again after difficulty is remedied.

When machines have been repaired.

Control of material movement.

Control of inspection.

What machines are most congested.

Whether workmen are ahead or behind schedule.

If production is falling behind and where.

Whether orders are broken into more than necessary.

Time when an operation must begin.

Standard or estimated time set for doing work.

Actual time spent in doing work.

When necessary to revise schedules to relieve congestion, or to meet conditions caused by absent workmen or breakdown.

Proper routing.

Where installation of additional equipment would be advisable.

Delay between operations.

Whether adequate supply of material is on hand.

Exact shop condition of any class of product or any order.

Comparisons of machines by departments.

Location of any order.

Completion percentage of any order.

Work released for next operation.

Standard hourly output of each operation.

Sequence of operations for any class of product.

Date a particular order will go to a machine.

Probable time of completing an order.

How many more operations are yet to be performed on an order.

Where to apply effort to secure an even flow of production.

102 The two introductory chapters dealt with graphics in the abstract; the chapter on ''Graphics in Warfare,'' and this chapter on ''Graphics in Industry,'' considered the subject in the concrete. A study of all four chapters should convince the most skeptical of the value of graphics in controlling production. Industry has made rapid strides, from the standpoint of efficiency in production, through the adoption of card systems and loose-leaf books; but while still useful and necessary, these have been found inadequate, when the ever increasing complications of modern industry are considered. It has been necessary to develop something more comprehensive, more simple, more elastic and more anticipative, and this something is graphics, based on the principle of visualization, on the assumption *that the eye is the pilot of the mind.*

CHAPTER V

IDEALS OF GRAPHIC PRODUCTION CONTROL

103 "Hey there! Where are you going? Can't you see that 'Stop' sign facing you? Back up and keep your eyes open."

104 With these words to a careless autoist, one of the efficient New York traffic officers went about his business "controlling" the endless procession of automobiles that is in daily evidence on the principal New York streets.

105 Imagine, you readers who have been to New York, what would happen daily at Fifth Avenue and 42d Street, if there were no traffic cops in evidence. Progress of automobiles would be much slower, congestion infinitely greater, accidents would be a common sight and the poor pedestrian would have a sorry time of it trying to dart in and out of traffic to cross the street.

106 *The traffic cop in any city is the best personification of Graphic Control that I know of.*

107 Now imagine a factory where material is allowed to flow at will, where there are no "Stop" and "Go" signs, where no one in particular is in charge of controlling the movement of materials, and you have much the same conditions—congestion of material, slow progress, lost parts, failure to maintain schedules and the like.

108 If it is necessary to control the movement of automobiles, trucks, street cars and people in our cities, it is just as necessary to control production in our factories, as there is a deadly parallel between traffic and production.

109 The above word-painting, so illustrative of what is in mind as necessary in industry, is but the picture of a

practical ideal of Graphic Production Control. There are other ideals, just as practical and equally as important, and which can be stated as follows:

A The ideal of service.
B The ideal of the efficiency as to the use of money.
C The ideal of economical production.

110 A few words regarding each is in order.

111 The Ideal of Service. The old slogan, ''The Public be Damned,'' and its companion cry, ''Business for Profit,'' are being recognized as not belonging to the new order of things. Industry has a long train of broken promises as to deliveries to its discredit, when better control would have resulted in more ''on time'' deliveries. The best customer is a satisfied customer, and in the future, when intense competition is the order, no ''take it or leave it'' policy, as to the kind of goods manufactured, or constant failure to ship on time, is going to hold customers for very long. The new business slogans, which far-sighted managers are adopting, are: ''The Public be Pleased,'' and ''Business for *Service* with Profit,'' and it will be those managers who will get the business. Graphic control is a direct aid to the furtherance of this great policy of service, and for this reason, if for no other, will become more and more popular with executives.

112 The Ideal of Efficiency as to the Use of Money. Unsystematic manufacturing is notoriously wasteful from the standpoint of money tied up in raw and semi-finished materials and work in process as well as in excessive or unnecessary equipment. Even in systematized manufacturing, more money is invested in materials and in equipment than is necessary. A greater turnover, with a minimum of investment in materials and equipment, will result only when manufacturing, from purchasing to shipping, is under positive control at all times. Here again graphic control comes in to show up delays and exceptions, and because of its ''anticipativeness,'' enables the far-sighted manager to manipulate his resources to better advantage. Idleness, whether in materials or equipment or floor space, means waste in money, which waste must be eliminated if

we are to become the most efficient and prosperous industrial nation on earth. It is simply a question of "obstruction *vs*. production."

113 The Ideal of Economical Production. We are living in an age of wonderful advances in labor-saving equipment of all kinds, the most modern methods of management and the latest devices of all sorts for factory and office, yet we have watched the cost of living steadily rise on all sides, with the end not in sight. The cycle has been and still is: increased wages—increased material costs—increased total costs—increased prices—increased wages, and so on the thing goes, always in the same direction—*upward.*

114 Certain it is, if we are ever going to pull "High Cost of Living" off its high horse, that this nation must give its attention to economical production, by which is meant—*quantity production of the proper quality at the lowest cost.*

115 To do this, production must be efficiently controlled at all times, and here again graphic control steps in as a decisive factor in prescribing standards and coördinating productive elements, to the end that the standards will be attained.

116 Such are the worthy ideals of Graphic Production Control: service to the consuming public, which makes for *good will;* better use of money, which makes for *thrift;* and more economical production, which makes for *reduced cost of living.* You may say that I am over-enthusiastic about this whole subject. My answer is, that for over ten years I have been thinking in terms of visualization; in fact, as early as 1907, in a series of papers in the pages of *The Engineering Magazine,* I presented charts which were designed to assist the manufacturing executive. To the skeptic I say, Go and use graphics and you will become as stanch a supporter as I, for the following reason:

117 The most advanced doctrine of management is that the unit sold is really *time*—time of equipment; time of workmen; time money is tied up in materials; time of clerical help; time of storage in a given place; time to make tools and jigs; time to remove material from one place to

another; time to set up machines; time of inspection. Any delays or enforced idleness at any of these points spells waste or loss, resulting in high costs which make for high prices. In proportion as manufacturers learn the costliness of idleness in industry in relation to the users of their products, in that same proportion will they welcome the efficiency of ''graphic production control'' to point out unerringly the *location* and *cause* of such idleness.

118 In the first place, what are we going to try and accomplish through the use of graphic control? Let me put it in the form of a standard:

119 *The time to consider the matter of manufacturing a definite number of units of production, in a definite time, within a definite cost limit, at a definite efficiency, is BEFORE the work is started in the shops, and not after.*

120 How will we convert this ideal into a practical reality? We can answer this by defining ''graphic production control'' as—*That mechanism which provides a means whereby, through visualization or graphical presentation, all details in connection with production can be intelligently planned in advance and efficiently dispatched; whereby each machine, man or gang can work with reference to all the other machines, men or gangs; whereby the shop management can, through advance knowledge, provide the necessary elements in the way of materials, machines, tools, drawings and labor.*

121 The above is virtually the definition of a principle, as ''control'' is the fourth principle of the author's six principles of Industrial Engineering: Investigation, coordination, records, control, standardization and relations.

122 To give the reader a proper conception of requirements to keep in mind in organizing the Graphic Production Control, the following is offered:

A A knowledge of what to make, the quantities, and the time in which to make them.

B Complete up-to-the-minute knowledge of stock receipts and disbursements.

C Prompt checking of requirements against the stock records.

D Maintenance of stock margins that will insure material being on hand when wanted.

E Analysis of the parts entering into the manufacture of the product, their operations and the estimated time per operation.

F Routing of orders analyzed to machines and gangs.

G Study of planning to avoid congestion.

H Rearrangement of schedule to meet unforeseen contingencies.

I Replacing spoiled or defective material.

J Charting progress of orders.

K Study of conditions interfering with prompt execution of plans.

L Delivery of material to machines and gangs.

123 To indicate the soundness of the above twelve points, which appeared in the author's "Installing Efficiency Methods," published in 1914, Mr. George S. Armstrong, in his book, "Planning and Time Studies," classified them under the headings which he considered the essentials of planning—

Demand
Material
Equipment
Time Standards
Control Mechanism

—as follows:

Demand.

A A knowledge of what to make, and the quantities and the time in which to make them.

Material.

B Complete up-to-the-minute knowledge of receipts and disbursement of materials.

C Prompt checking of requirements against stock records.

D Maintenance of stock margins that will insure materials being on hand when wanted.

L Delivery of materials to machines and gangs.

Equipment.

K Study of conditions interfering with prompt execution of plans.

F Routing of orders analyzed to machines and gangs.

Time Standards.

E Analysis of parts entering into the manufacture of the product, their operations and the estimated time per operation.

Control Mechanism.

J Charting progress of orders.

H Rearrangement of schedules to meet unforeseen contingencies.

I Replacing spoiled or defective material.

G Study of planning to prevent congestion.

124 Now let me ask any industrial executive this question: Is there anything about any of the above twelve points that is impractical or visionary? Are not all of them accepted by industry at large to-day? Well, then, if you believe in these twelve points, you can have Graphic Production Control, if you will subscribe to a few simple rules, which you will also find are in almost general use in industry, as follows:

A No work should be undertaken in any department of the plant without an order in writing.

B No orders are to be started until they have first passed through the Control Department for attention and scheduling.

C No job will be considered available until everything *is* or *will be* ready for the work.

D No job is to be changed after starting until the Control Department has been notified and arranged for the changes.

E No part of an operation is to be started by a succeeding operation until the Control Department has arranged for it.

F Sufficient work must at all times be scheduled ahead so that there will be no likelihood of a machine or gang

running out of work. Better to schedule too much work than not enough.

G No material is to be moved to a starting operation without the knowledge of the Control Department.

H Jobs must be arranged and given out in the order scheduled.

I The routing indicated for a job is not to be changed except on authority of Control Department.

J Time cards must register actual times and amounts produced.

K Each operation must be reported on a separate card showing time and count.

L Idle time must be shown on a separate card.

125 What you may expect in the way of results from Graphic Production Control if the requirements are fulfilled and the rules lived up to, can be stated as follows:

A Reduction of raw materials and work in process carried.

B Prompt ordering of material required.

C Notification to foreman of all operations necessary to make any piece, with the sequence in which the operations are to be performed.

D Prompt ascertainment by the foreman of the whereabouts of all material and supplies necessary to fill each production order.

E Fuller utilization than formerly of the capacity of each machine.

F Fuller utilization than formerly of the capacity of each workman.

G Prompt following of each operation in any one department by the one ordered to follow it.

H Prompt following of the work in any one department by that in the department next scheduled to follow it.

I Insight into the state of progress of each job in process.

J Information as to the lack of capacity of any one machine.

K Information as to the lack of capacity in any one department.

L Reduction of overhead.

M Reduction of material cost.

N Reduction of direct labor cost.

O Reduction of indirect labor cost.

P Better relations between department heads.

Q Better relations between department heads and workmen.

R More rapid production.

S Avoidance of congestion in any one department.

T Avoidance of congestion of any one machine.

Chapter VI

THE LAWS OF GRAPHIC PRODUCTION CONTROL

126 The Bible might have contained this commandment, "Put not thy faith in devices, forms and systems, but be ye chiefly concerned regarding principles and laws, for in their acceptance there is much reward."

127 Now the point is—after providing a practical ideal and defining the principle of control—what are the laws through which we can secure the results outlined? They are several in number, as follows:

A Centralization. Given a plant and equipment, with an organization to handle the work, the manufacturing of all that is designed by the engineering department and sold by the sales department can be handled to best advantage only when the details, instead of being considered independently by each department, *are controlled by one function.*

B Scope of Control. Control should be as much concerned with engineering, purchasing, tool and jig work, as with foundry, machine shop and assembly methods and operations.

C Draw versus Push. Work should be *drawn* through a shop from the erection end, and not *pushed* through the engineering, purchasing, foundry and machines to sub-assembly, assembly and erection.

D Requirements. Requirements in the way of units to manufacture must be known in advance, so as to allow time to arrange for proper control.

E Assignment of Work. Assignment of sufficient work must be made in advance, to keep equipment and men oper-

ating at maximum capacity, without injury to condition of equipment or health of men.

F IMPORTANCE AND AVAILABILITY. Relative importance and availability of all work must be known and considered in controlling production.

G OPERATIONS. Operations must be standardized as to sequence and manner of working, and estimated or standard times established for all work which is to be graphically controlled.

H LABOR. No man should do any work that can be performed as well by another with less skill and at less expense, or with greater skill or more expert attention.

I EQUIPMENT. Equipment should be standardized, kept properly repaired and the proper balance maintained for efficient production between types and sizes.

J MATERIALS. Material should be under positive control at all times, to insure adequate quantity, proper quality and efficient movement.

K STARTING OPERATIONS. The selection of a starting operation, whether making a jig, buying material or starting a machining operation, is governed by that element the starting point of which *is furthest from the finishing point.*

L SUCCEEDING OPERATIONS. No succeeding operation should be started in a plant when its ratio to the preceding operation *is less than one to one.*

M LOTS. Lots should be directly proportional to the ratio of handling time (set-up time) to the operation time, and inversely proportional to the size or weight or value of the material.

N COSTS. The same mechanism that is used in graphically controlling production, should also furnish direct costs of production as a by-product.

O ORGANIZATION. The functions of control should be properly determined and authority, duties and responsibilities worked out and followed.

128 The laws of control are much more fundamental and important than a casual reading indicates. Unless they are accepted and obeyed, no effective production control is at all possible, and the reason why so many concerns secure

only ordinary results from their control methods is because there is a violation of one or more of the laws.

129 In one case a survey resulted in the following report, which is self-explanatory and shows conclusively that many of the laws were not considered:

130 After our preliminary study of your operations, we tried to match betterments against your requirements as a test, but found we could do little, for the following reasons:

A We did not find an analysis of parts from the standpoint of importance to sub-assembly and final erection. Lacking this, it is impossible to work up sequence and flow of parts and sub-assemblies.

B Little has been done in the matter of standardizing operations or supplying records with sequence of operations on parts. Without this knowledge it is impossible to route parts through the shops.

C There are no estimated times for operations on file. This is necessary in planning, in order to estimate the length of time to allow for work at the different points of travel.

D While you have part orders, there are no regular manufacturing orders for building a definite number of certain models, making it a difficult matter to know what to control.

E You have orders in the plant for too long a time. This not only holds up your records but increases the chance of errors creeping in, or having the orders lost or sidetracked.

F You do not have your stock situation under the kind of control that would enable the planning department to depend upon these records, which would mean constant changes and corrections in schedules.

G Your time reports are loose and unreliable, as the men keep their own time or your clerks enter what the men tell them. Correct times and correct counts are essential in watching and controlling progress, from day to day, of work which has been planned.

H You have too many changes and errors, during

process of manufacturing, to schedule intelligently the work of assembly and testing. These departments, not knowing what is coming to them from serving departments, cannot get things in readiness in advance. Very often they have to do extra work because of a failure to complete work on a preceding operation.

I Due to the present congestion in the shops, it would be exceedingly difficult to control production efficiency without a full knowledge of what is in shop and the conditions with reference to completion.

J Because of the lack of advance information, departments do not know in all cases what is coming to them until material arrives on the floors. Under these conditions no scheduling is at all possible.

K Weaknesses in both tool room and inspection departments would interfere at present with attempts to schedule work properly through the plant.

L As was repeatedly pointed out, there is an almost entire absence of systematic shop procedure, the unforeseen and the unexpected largely governing the department heads.

131 Yet this was a supposedly modern plant making a high-class product, and the conditions outlined prove conclusively the need for obeying the laws of production control. Let us consider these laws, one at a time, that their meaning may be clearly understood.

132 *A* Centralization. Little argument should be needed to show that one function can coördinate properly, where several functions become antagonistic. One function can consider the needs of the various divisions, where, if left to several, there is a tendency toward confusion and lack of coöperation, each feeling that its own needs are of paramount importance and should therefore be considered first. One function can keep the *plant ideal* constantly before it, whereas several functions mean several conflicting ideals, resulting in that game we all know so much about—"passing the buck."

133 *B* Scope of Control. Control, to be efficient, must

be comprehensive and all-embracing. If the purchasing is not included in the control plans, how can efficient planning be carried on in the shops, when its efficiency is in a sense dependent on the efficiency of the purchasing function? If the engineering function is in no way guided by shop requirements, how will the control function be able to plan properly, not knowing what to expect from the engineering division, and when? If the tool and jig work or the making of patterns is a side issue, what basis will the control function have for scheduling foundry work or the starting of machining? If the foundry or forge-shop production is not tied into the machine and assembly work, what plans can the control function make, not knowing what castings or forgings to depend upon? In other words, a control function which seeks to control simply the operations of machining and assembly, means no control at all and is always at the mercy of the shortcomings of others.

134 *C* Draw versus Push. Assembly and erection foremen have told me, time and time again, that they could not schedule work ahead, because they did not know what was coming to them from the machines. Subsequent investigations have always borne out these statements. How could they be expected to do so, when in a guess-it-will-get-there-all-right manner, an attempt is made to start work in and through the machines without definite reference to where it will be from time to time and where it will end up? Further, I have often seen plenty of work at machines, with men working at a fair rate of efficiency, while the assembly and erection men were either hungry for parts or working on whatever they could get, but did not want, so as to keep busy. Instead of planning to keep the machines busy, with only a general idea as regards the erection, the task should be to keep the assemblers and erection men busy on what they should have, and then fit the work in and through the machines to match this line-up. In other words, the completion or wanted times are known factors or control constants, and the planning should work back from these constants.

In one study made of a large plant, the erection figures showed these results:

Unit	*Starting*	*Daily Productions*
1	March 25	0, 0, 26, 16, 6, 4, 8, 8, 15, 0
2	April 8	0, 2, 6, 11, 9, 4, 0, 5
3	April 12	0, 0, 3, 3, 1, 0
4	March 27	0, 5, 5, 19, 15, 5, 15, 10, 26, 18, 18, 5, 4
5	March 31	10, 12, 7, 3, 8, 12, 19, 5

It should be obvious from a study of the above figures that nothing approaching an even production flow, or uniformity, or efficient working by men and gangs, or even good planning, is at all possible under such conditions. It should also be evident that the fault does not rest with the assembly department, as it assembles what it receives, and, not dominating the situation from the standpoint of planning and control, can exert only an indirect influence with reference to what should be delivered to it, as well as when, and the quantities. The results, however, are:

a Disorganization of the department.

b Breaking up and shifting of gangs.

c Putting men familiar with one line of work on operations with which they are not so familiar.

d Loss of production.

e Loss of time waiting for materials when shifting gangs.

f Increased costs of assembly.

The fault in such a case as this can be laid to violation of this law, that work should be drawn through a shop from the erection end and not pushed through, with the drawing including all factors affecting production.

135 *D* Requirements. Unless requirements are known in advance of starting work, no control over production can possibly be exercised, for the very good reason that there is no time allowed to plan properly and dispatch. In one case it was found that engineering work on the product and work on the tools and jigs should have started months before they did start. In other words, in working back from the "completion wanted" date to the time the important and critical items should be started, to allow for efficient manufacture and proper coördination, the elapsed time was

entirely insufficient. The control function, to operate properly, must know, sufficiently in advance, what is to be made, the quantities and the time completions are wanted. This cannot, of course, always be done, but experience proves that it can be done much oftener than it is, as these chapters will indicate.

136 *E* Assignment of Work. Unless sufficient work can be scheduled against machines, men and gangs, what is the sense of going to the expense of creating a control function? To go into four well-known and representative plants, where attempts were made to plan work and find idle equipment times of 30, 35, 40, and 50 per cent., respectively, is a sad commentary on production practice in this age of modern methods. In one of the cases—the most serious—the causes of faulty assignment were found to be:

a Shortage of manufactured material or purchased parts.

b Jigs and tools not in readiness.

c Faulty design requiring experimenting in shops to correct.

d Changes in design after manufacturing had been started.

e Making special parts and sundries.

f Delayed orders.

g Changes in schedules.

h Failure to schedule machines properly.

This law should need little argument to justify its inclusion in this list of laws. Its soundness and logic are evident, but it is one that is violated most in industry.

137 *F* Importance and Availability. In a plant making large gas engines, the assembly foreman once said that if he could get the parts he wanted, in the order that he knew would make for the greatest efficiency, he could get out much more production. I asked him why he could not get what he wanted when he wanted it? He stated that the foundry, forge shop and purchasing department usually gave him the things they thought he needed, or the things which seemed easiest to make, but which he did not need until toward the middle or ending of the work. As a result,

I asked him to take his very complete bill of material and mark, in one-two-three order, the arrangement of the parts with reference to their importance to him, and I told him that I would see if, in the future, we could not get the parts to him in the order named. He did so, and it was a simple matter to rearrange the list according to importance and schedule the foundry, forge shop and purchasing department accordingly, rendering available the things necessary to efficient assembly and erection. It was simply a case of "first things first." In this connection, it was found that the order of importance to the assembly end was not the order of importance to the machining departments, nor to the foundry or the forge shop—but this phase will be treated under another heading. The aim of this law is to furnish a manufacturing ideal, so as to lay down on the assembly floors the proper flow of work in sequence.

138 *G* Operations. Unless we know the sequence of operations, we are in no position to schedule properly the flow of parts from one place to another. If we do not know the approximate time an operation will take, we cannot say how long a machine or man will be engaged on it, and are therefore in no position to coördinate the operations and the equipment. We must also know the manner in which the work is done, so as to have a basis for time estimates and for betterments in the manner of performing. Consequently efficient control depends upon having a function at work standardizing operations, to determine sequence, method of manufacturing and the time an operation should take.

139 *H* Labor. This is a law the logic of which is generally accepted in industry but not always obeyed. If a laborer can bring material to a machinist or structural worker or molder, the higher paid skilled worker should not be called upon to do so. If an expert mechanic can shape, grind and dress tools better than the machinist or structural worker, common sense dictates that the expert mechanic should be given this work to do, that there may be uniformity and greater efficiency in what he does over what would be the case if all of the workers were allowed to take care of their own tools. The same logic applies with reference to repairing machines, inspecting the work and the like.

140 *I* Equipment. Equipment unstandardized, out of repair and out of balance, means the manufacture of a product at high cost, as well as delays and confusion. What a machine can do should be a known fact and not a matter of guesswork. To fail to anticipate breakdowns and make repairs out of working hours, is to court loss of production while repairing during working hours. To have equipment unbalanced, means that some machines will be congested while others will be idle for part of the time.

141 *J* Material. Material must be just as much subject to control as labor and equipment, as it is one of the most important factors requiring coördination. There must be a knowledge of what to make, the quantities and the time in which to make them. There must be complete and up-to-the-minute knowledge of stock receipts and disbursements. There must be prompt checking of requirements against stock records. There must be a maintenance of stock margins that will insure materials being on hand when wanted. If the material situation in a plant is put under proper control, one of the stumbling-blocks in the carrying out of good planning will be removed. Many an otherwise efficient production control installation has come to grief because the control over material was more fancied than real. It is, of course, fully realized that in these times there is great difficulty in efficiently controlling material, but the methods which will be outlined in this series will show that material can be controlled in the average case much better than is usually done.

142 *K* Starting Operations. One of the most difficult questions to answer in manufacturing is, "When should we start a certain piece of work?" In many cases coming under the writer's observation the plan was one of starting work through the foundry, forge shop and machines and then hoping and praying it would be assembled and shipped on time. The purpose of graphics is to substitute something scientific for guesswork and prayer, through the application of this law of starting operations.

143 Let us analyze Figure 3 for a moment. An order is received on June 3 and is wanted on August 28, which means that 75 working days are allowed in which to make

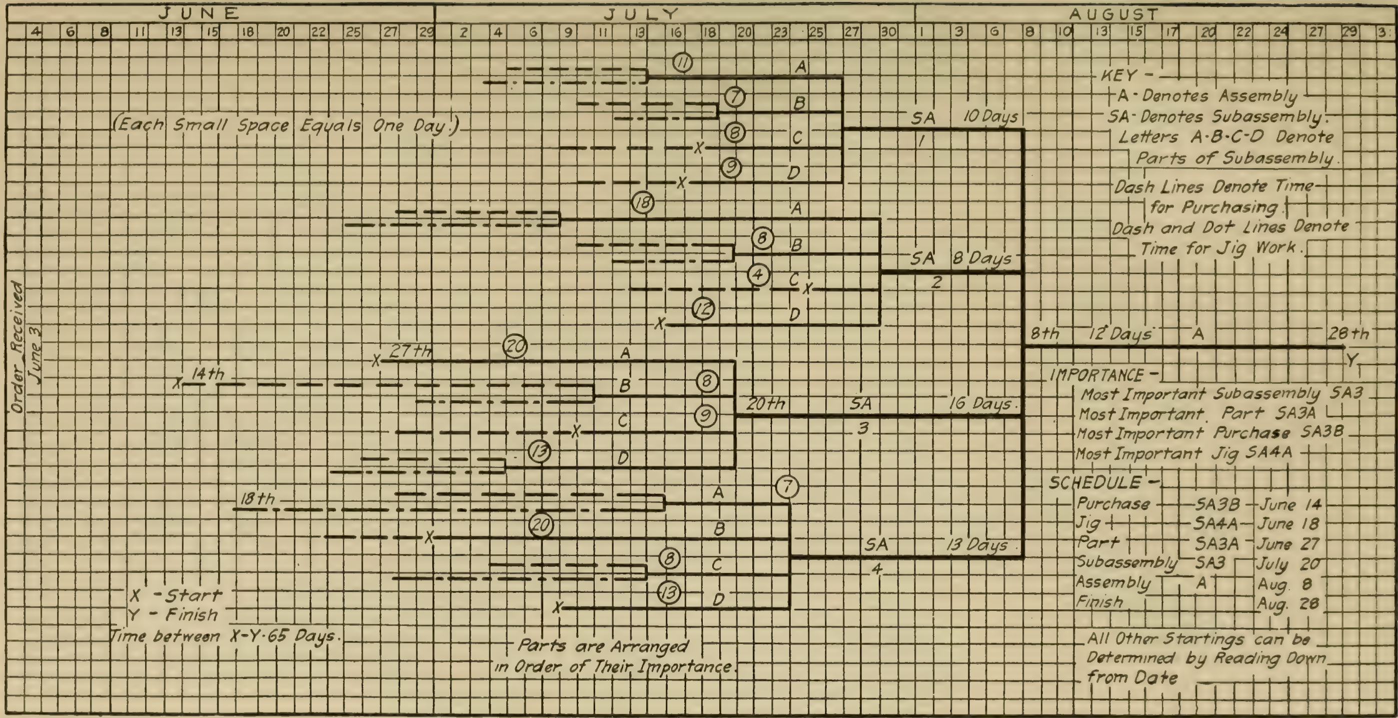


FIGURE 3. MANUFACTURING CONTROL AND SCHEDULE

the unit or units. Now, instead of *pushing* things through the shop in a haphazard manner, let us first of all observe this law of *drawing* the work through. We will first gather data as to the time it takes to do the various kinds of work necessary to complete the order. Starting back, therefore, from August 28, on graphic paper (each small space equaling one day, six days to the division), we find that final assembly will take 12 days; that there are four sub-assemblies taking 10, 8, 16 and 13 days, respectively, and that the various parts of the four sub-assemblies take the times indicated by the circled figures on the top of each line. Going

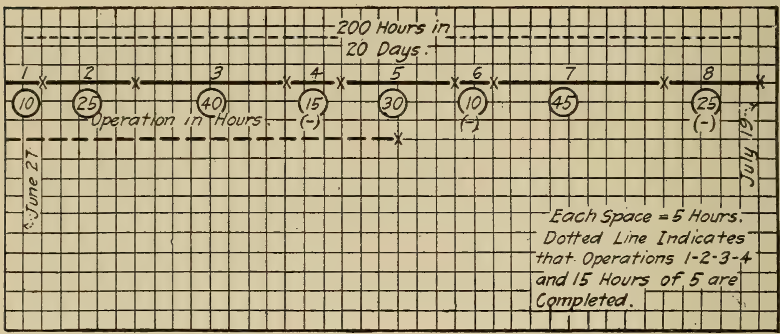


FIGURE 4. A PLOTTING OF OPERATION SEQUENCE

back from Y still further, we set down the times to make jigs and procure materials.

144 What do we find? The most important fact is that we must start our activities on June 14 (marked X), and that the time in which to manufacture is 65 days (June 14 to August 28). We also find (according to the law of importance) that SA3 is the most important sub-assembly for the assembly floor, and that SA1A, SA2A, SA3A, and SA4A are the most important parts to sub-assemblers. The most important part from the standpoint of machining is SA3A, the most important purchase SA3B, and the most important jig SA4A. *These are the critical points.* By as much as we lose time at any of these critical points, other things being equal, by just that much must we advance the finish date. If, for instance, we do not get our jig work started

until June 25, instead of June 14, our completion date will be September 9.

145 A brief study of the chart will show it to be self-explanatory, and will prove conclusively the superiority of graphics over the usual method for laying out a manufacturing program and controlling production.

146 *L* SUCCEEDING OPERATION. By this law we can properly control the flow of operations of parts through the shops. Let us assume that part SA3A (Figure 3), taking 20 days or 200 hours, is divided as follows:

Operation	*Hours*
1	10
2	25
3	40
4	15
5	30
6	10
7	45
8	25

147 If we work on the assumption that we will complete the 200 hours of work by finishing the pieces at each operation, before turning the work over to the next operation, we will have a graphic record as shown in Figure 4, and can show progress by the dotted line as indicated.

148 Let us look at it another way, however,—of releasing operations from one to another, as pieces are completed, *in cases where it is found safe to do so*. If we released one-half of operation 1, or five hours' work, to operation 2, we would be giving the latter 12½ hours' work, because the ratio of the succeeding time to the time released is 2.5 to 1; that is, 25 ÷ 10. If we released 10 hours' work from operation 2 to operation 3, we would be releasing 16 hours to the latter, as the ratio of the succeeding operation to the preceding operation is 1.6 to 1, or 40 ÷ 25. In both of these cases we release a *greater* amount of time per hour, from one operation to the next, for which reason it would be safe to schedule from 1 to 2 and from 2 to 3.

149 From operation 3 to 4 (40 hours to 15 hours), we have a different condition. If we released 20 hours' work

from 3 to 4, it would give the latter operation only 7½ hours' work, the ratio being 0.375 to 1, or 15 ÷ 40. *In other words, if a man secured 0.375 hour's work from the preceding hour's work, he would be idle 0.625 hour while waiting for the next hour's work.* This same reasoning applies as regards releasing work from 5 to 6 and from 7 to 8, and operations 4, 6, and 8 have been marked (—) to indicate this.

150 On the basis of this law we can turn out the 200

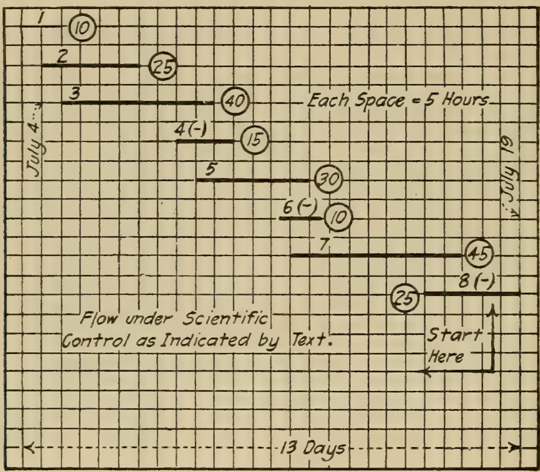


FIGURE 5. REPLOTTING OF OPERATION SEQUENCE SHOWN IN FIGURE 4

hours' work referred to in less than 20 days, as will be seen from Figure 5. Beginning from the last operation and working backward, we would plot operation 8 (25 hours) from July 19. As the relation of the time of operation 8 to operation 7 is less than 1 to 1, we should not turn any work from 7 to 8 until all of the parts have been finished at that operation, although we could release the work when approximately ¾ of the parts had been finished. Hence we would start back from the end, or near the end, of the operation 8 line and plot in the 45 hours for operation 7. Work at 6 can be turned over to 7 practically as fast as it is finished, as the ratio of 7 to 6 is greater than 1 to 1. If the reader will, therefore, trace through to operation 1, it will

be seen that recognition has been given to this matter of ratio all through the eight operations.

151 As will be noted by the above method of graphing, the 200 hours of work can be done in 13 days instead of 20 days.

152 The ratio in each case, as found by this formula

$$\frac{\text{Succeeding operation time}}{\text{Preceding operation time}} = \text{Ratio}$$

and worked out for the list of operations, would be as follows for each one:

Operation	*Hours*	*Ratio*
1	10	2.5 to 1
2	25	1.6 to 1
3	40	0.375 to 1
4	15	2.0 to 1
5	30	0.33 to 1
6	10	4.5 to 1
7	45	0.55 to 1
8	25	....

153 Here is another important point in connection with this law. Multiplying the time finished at any operation by its ratio will give the available time for the next operation, through which we can always have an inventory of labor, the same as we have an inventory of materials. For instance, 2 hours completed at operation 1 multiplied by its factor (2.5 to 1) means 5 hours of work for operation 2. If we complete 7 hours' work at operation 3 and multiply it by its factor (0.375 to 1), we have, as the time against operation 4, the sum of 2.6 hours of work. This affords us an opportunity to deduct from one operation for time turned in and add to the succeeding operation, thus furnishing a continuous balance of labor to be performed against operations.

154 *M* Lots. One of the factors entering into high costs of production so often met with in industry, is the practice of making a few parts of a run of parts, then tearing down the machine for a rush or forgotten order, and again setting up for the displaced job. By properly controlling the pro-

duction, this tearing down and setting up can be reduced to a minimum, but the problem becomes one of determining the size of lots. In estimating operation times, it is usually known what the set-up times are, and it goes without saying that the greater the margin of set-up time to the time of the operations themselves, the larger should be the lot run through. When the set-up time is a small item, a small number to the lot would be consistent. This part of the law is, therefore, important in determining the size of the lots to manufacture.

155 On the other hand, how often have we seen valuable pieces or heavy pieces being made in quantity, which keeps a large amount of money tied up in stock or in work in process. Therefore the greater the value of the material or weight of the part, the less should be the number of the lot, making this part of the law just as important as the other.

156 *N* COSTS. One of the executives of a Middle Western plant once asked my advice on a cost problem, as regards which of two plans was the better. He stated that both the treasurer and the production manager wanted a cost system, but that each one wanted a different kind of a system. The treasurer wanted a financial accounting system, which would give him everything he wanted with which to render to his directors a proper accounting of where money was spent, when, how, and why, but in so doing making the shops fit into his plans, instead of basing his work on manufacturing conditions. The production manager, on the other hand, had a theory that he was there first of all to get out production as rapidly as possible; next, to keep the expense down to a minimum; and finally, to render a proper accounting for the time and cost put in on work.

157 In other words, the one wanted financial costs, the other engineering costs; the one wanted to be a historian, delving into the past, while the other preferred to be a prophet, looking into the future; the one would make costs a prime consideration of the business, the other would make them a co-product of manufacturing.

158 Under "graphic production control" direct costs would be an engineering proposition and would be a part

of the control mechanism, for the reason that the same records used for planning and scheduling and controlling the manufacturing would also be used for keeping and compiling costs, leaving the rest to the accountant.

159 In brief, the production manager was right.

160 *O* Organization. It is of the utmost importance, in providing "graphic production control," to organize the work properly. The first law outlined the value of centralization; this one considers the matter of coördination, of considering duties, functions, responsibilities and relationships. If the work is handled in a haphazard manner, with no head and tail to things, it will not be long before disorganization sets in, and in the end "graphic production control" will either receive a "black eye" or be "damned with faint praise." If things are to be done, some one must do them. If things are to be done, there is a good way to do them. Therefore the things to be done, the people to do them and the manner of doing them must be brought together and coördinated—that is, organized. There should be nothing left to guesswork or a matter of "I didn't know" or "I understood So-and-So to say so-and-so."

161 A review of these laws will indicate how important "graphic production control" becomes when they are properly considered and woven into a well defined production plan. Obey the laws and results will be forthcoming. Violate them and there is a corresponding punishment as sure as the punishment we receive when we disobey the laws of the land, of health or of nature. Further, a study will indicate how important a proper consideration of law is in the treatment of production problems, instead of without reference to sound theory.

Chapter VII

FUNDAMENTAL CONSIDERATIONS IN GRAPHIC PRODUCTION CONTROL

162 In considering the inauguration of a system of Graphic Production Control, certain questions and doubts arise as regards what to install and how to install it, as well as when the various steps should be undertaken and the order of their installation. With these points in mind, it was deemed advisable to outline certain fundamentals which would, in a general way, act as guides.

163 The Chief Factors in Processing. The three primary factors influencing the processing of materials are:

A Plant Equipment and Arrangement.
B Shop Transportation.
C Production Methods.

If we analyze these three a moment, it will be found that the best plant and equipment, with the most efficient shop transportation methods, will not insure the best results if the methods of production control are at fault. On the other hand, given the most efficient methods of production control, with only a fair degree of efficiency as to equipment arrangement, and transportation, and better results will be forthcoming. In other words, *provide proper production control first,* then tone up and make better the arrangement of plant and the shop transportation of materials.

164 Elements in Production Control. Let us determine the elements which the control mechanism will control. The activities of the workmen must be guided or there will be only ordinary results in production. The movement of

material as to purchase, receipt, storage, issuance and transportation must be intelligently guided. The work to be done, or the operations, must be known and properly defined. The equipment—jigs, tools, fixtures and machines—must be in readiness for the work that is to be done. Hence we have four elements in control, under which can be classified all factors influencing production—

Labor, which does the work.
Material, on which the work is done.
Operations, the work done.
Equipment, with which the work is done.

165 If one or more of the four elements are neglected in, or eliminated from, any plan of production control, graphic or otherwise, do not look for any substantial results, *for they will not be forthcoming.* Control brings labor, material, work and equipment together and coördinates them for efficient manufacturing.

166 Functions of the Control Mechanism. In arranging for Graphic Production Control, the functions of the control mechanism are as follows:

A Be responsible for the planning, routing and scheduling of all production details.

B Coördinate the work of the engineering, purchasing, cost, tool and manufacturing departments.

C Work in conjunction with the various departments.

D Act as a clearing house for all production data needed to guide properly the manufacture of a product.

167 Incidentally the best name for the control mechanism is *Control Department* or *Division,* and it will be so termed in all subsequent discussion.

168 Devices of Graphic Production Control. There are many elements to be considered in graphic presentation. In other words, there are numerous ways by which facts can be presented in a graphic manner. Careful analysis and the results of our experience reveal the following:

A General Charts, showing results, past and present; tendencies as regards future happenings; essential information of a general character, all to be used for ref-

erence purposes, in gauging operating efficiency, and constituting the control according to *results.*

B PROGRESS CHARTS, which, combined with order requirements, show graphically the conditions and present status of all orders, and constitute the control according to *orders.*

C MATERIAL CHARTS, which show, in graphic form, the condition and flow of all essential materials, and constitute the control according to *material.*

D CONTROL BOARDS OR CHARTS, which furnish a true picture of the department or plant in miniature, and constitute the control according to *equipment, or working places.*

E DISPATCH BOARDS, which furnish the point of contact between control boards or charts and the shop operations, and constitute the control according to *labor.*

F PRODUCTION DIALS OR CHARTS, which indicate graphically the productions of a department or shop or special product, in such a way as to indicate to the workmen their degree of performance on a particular task, and constitute the control according to *attainment.*

169 How much is necessary of all these devices in a given case depends on the complications met with, the nature of the manufacture, and how far the concern desires to go in controlling its production. As can be seen, the control of equipment graphically does not furnish a quick reference as to the condition of orders or the condition of materials. As regards *B, C,* and *E,* each can be considered as going with one or both of the others, cross-indexing or double-entry recording, so to speak. Generally speaking, the control board can be looked on as the master control, with progress charts and material charts taking care of the orders and materials. Dispatch boards are always necessary in any proper plan of production control, and consideration will show that general charts (*A*) and production dials or charts (*F*) can be used to advantage in any business.

170 WHAT TO CONTROL. Systems of production control must deal primarily with one of three things,—material,

labor or equipment,—and it is sometimes difficult to determine which should be considered as the factor in the production work. In some shops—repair and jobbing shops, for instance—material, or the *work* to be done, requires the closest attention and would therefore be the element to be controlled. In a machine shop making a regular line of product, the *equipment* is the element to be carefully considered, in order to manipulate it to best advantage. In controlling the work of a large maintenance gang, *labor* would be the basic factor to consider. In other words, the rule to follow is this: *What is to be controlled depends upon what must be given the most careful attention.*

171 Duplication in Methods. The next point to consider is whether or not a graphic production plan will constitute the primary and basic record, and what will be necessary in the way of collateral or supporting information. If, from the nature of the business, results must be compiled from cards or sheets which will in themselves aid to a considerable extent in controlling production and assist in reaching sound conclusions, the work of transferring this information to graphic boards and sheets is not only duplication of effort, but will result in incomplete posting to boards and sheets. If you can do things from two different sets of records, it will be found that neither is always correct, and as a result both are never relied upon. The aim should be to make the graphic record the original source of information, in so far as this is possible. If the thought is to make the graphic feature only a supplement to other and seemingly more important production methods, the best possible advice is not to plan on any elaborate methods of graphic control. In most cases, a graphic plan will be all that is necessary to control production properly, and it should be the source of information and the keystone in the industrial structure.

172 Accuracy of Methods. Whatever is devised must be adjusted to the detail and accuracy that are necessary or desirable. How far a graphic system should go; the complications of the business; the inefficiency of the department or plant; whether the plan is to be simply a guide or to serve as the basis of all important decisions, are points

which must be considered before a graphic proposition is devised and installed, as changes later on will prove costly.

173 What Control Means. It should be borne in mind that the term "control" is not a substitute for thinking and reasoning. A graphic production control plan is at best only an inanimate thing, capable, because not a human being, of no real thinking at all. To present information graphically and then expect the presentation to work wonders in itself, is to expect the impossible. If you harness a team of horses and jump to the seat without the reins in your hands, you will have no control of the horses. With the reins in your hands, however, you can guide and direct the team where you please. The same with graphics. The formula is: Graphics plus gray matter = control.

174 Elasticity. The plan of graphic control devised must be elastic instead of a hard and fast, rigid, arbitrary mechanism. Men say to me, "Suppose this and that happens, won't it destroy the effectiveness of the plan?" My reply always is, that under a proper plan, this and that and the other thing can happen and the plan will take care of it all. A machine may break down, or a worker may go home sick, or there may be a fire, or a customer may be forced to have his order completed at once, or material may be found defective, and unless these conditions can be quickly and properly taken care of by the graphic production methods, the plan does not prove up and is worthless. The plan, when making changes due to conditions such as above outlined, must not entail a long series of changes in supporting records and systems. It must be designed, as far as possible, like a battle-ship, so that certain parts can go out of commission, if necessary, without disarranging the whole.

175 The Start. Doubt often arises as regards how to start—whether to begin in a small way, gradually extending and refining as the work progresses, or to get everything in readiness before the installation of production methods. Take operation times as an example. Will we determine accurate standards before putting in production methods, or use estimated times to start with, and as rapidly as possible during the installation of the work make the refinements necessary to reduce the estimates to terms of accurate

standards? In our work we recommend starting with estimated times, as the time that would otherwise be taken to determine accurate standards and arranging for a proper start can be used to advantage in making a real beginning toward controlling production and thereby securing better results.

176 Information must be compiled regarding the product, as this determines what is to be made; material must be placed under better control, in order to know what is on hand and where it is; time of labor must be accurately recorded, in order to know what is being made and how long it is taking; information must be available as to equipment, in order to know where work can be scheduled. While all this is being done, estimated times can be compiled and work in with the rest of the program, and by following such a program results can be secured from the start. Refinements can be made as the work progresses, and in the long run the installation will be as complete as if greater preparations were made at the start, with the advantages of taking less time and securing better results.

177 The beginning should not be too ambitious, or there will be a case of mental indigestion on the part of the factory personnel. Begin slowly, but make every step count for something. Take the starting departments first, keeping in mind, however, the schedules of the finishing or assembly departments. In other words, keep in mind the third law of Graphic Production Control: *i.e.,* Draw *vs.* Push.

178 Types of Control. There are many different types of manufacturing which must be handled differently, the differences being more in manipulation and in devices—the principle and the laws being the same. No stereotyped plan of Graphic Production Control will fit every case, and because of this it was decided to outline, in a general way, the basic differences. Types of manufacturing can be classified as follows:

A Unit manufacturing.
B Many products—few materials.
C Many operations—few machines.
D Foundries.

E Group of sub-factories.
F Simultaneous manufacturing.
G Yard and repair work.
H Laboratory, technical and secret process.
I Woodworking plants.
J Structural plants.

A few words regarding each are in order:

179 *A* UNIT MANUFACTURING. In a factory of this type, a product is started at the first operation and retains its identity until it becomes a finished product. Rubber hose is a very good example of this type of manufacturing, as is also insulated wire. Many so-called assembly plants resemble this type, due to the fact that merely labor and, sometimes, material are added to the original unit at different points in the factory. The outstanding feature in such a factory is that departments must balance; they must have the same capacity, although performing different operations. If the number of changes is small, and this is the case in many instances, it is entirely possible to control the factory adequately by simply controlling the different departments without reference to machines or operations. If, however, there are many machine changes, some form of machine control is necessary in order to plan the flow of work to and from the machines. In this type of manufacturing it is not necessary to watch work in process so carefully, since an accumulation means the failure to meet schedules and shipping dates. With certain exceptions—numerous machine changes, for example—the product according to departments is the factor that must be controlled.

180 *B* MANY PRODUCTS—FEW MATERIALS. In this type of manufacturing, a large variety of products are made from comparatively few materials, such as novelties, buttons, bed springs and pneumatic tires. In the latter case, the same type of calendered stock may be used in a variety of tires, merely being cut to suit the requirements of certain products to be made. It follows from the nature of the work that the prime consideration is the maintenance of a proper balance of partly finished materials which may be drawn upon for the greater variety of products into which

they go. Hence the control of the factory develops into the control and balancing of partially finished goods. Schedules by departments, or groups of machines, and in some cases according to individual machines where changes are many, will furnish the control necessary to secure results. Contrary to the first type, it is necessary in this type for the Control Department to watch the work in process, in order to keep the investment in materials at a minimum. In this class the chief elements to control are materials and products according to departments, and in some cases according to machines.

181 *C* Many Operations—Few Machines. In a case of this kind, such as the manufacture of typewriters, automobiles, engines, and the like, thousands of operations on a large number of parts are performed on a comparatively small number of machines, as, for instance, in one case—30,000 operations, 1800 parts, 300 machines. The control of equipment is of far greater importance in this type than in the preceding types, because of the large variety of operations that can be performed on a single machine. Cost and production considerations necessitate reducing the number of changes to a minimum; and, to this end, any scheme of graphic control which does not take equipment into consideration will not furnish the control desired or necessary. In this type of manufacturing, material control is necessary to insure a uniform flow of material to machines and assembly benches and floors, as well as to keep the investment in materials to the lowest possible point consistent with economical manufacturing. It is also important to watch the progress of orders on account of the large variety of parts and operations.

182 *D* Foundries. In this type working spaces are to be kept filled with work and the molders and coremakers must be scheduled to these working spaces. As can be seen, the element to be controlled is labor, according to working spaces. There must also be a knowledge of the progress of orders.

183 *E* Group of Sub-factories. An example of this type of factory is the incandescent lamp industry, where under the same roof may be a chemical works, a wire-draw-

ing plant, a glass-blowing factory, a lamp factory, and in some cases four or five others. Each of these sub-factories is usually one of the preceding types, and it is necessary, in a plant of this kind, to adopt a blanket schedule for the entire group and plan each of the factories to conform to this blanket schedule. The result of an analysis of a plant of this kind will usually be the installation of different methods in the different plants, or departments of the plants. Work in process must be carefully watched. In this type of factory the person in charge of the control work needs to have a general idea of the cost of doing work. In the preceding types he knows that eliminating machine changes, idle machine time and delays will reduce cost, and he can work to this end. On the other hand, in the present type of factory, the control schedule involves piling up investment in materials and finished products of the sub-factories, and the proper coördination of the activities of these various factories very frequently involves a knowledge of the financial situation.

184 *F* SIMULTANEOUS MANUFACTURING. Manufacturing of this type differs from the preceding types in that, instead of centralizing the manufacture of a certain portion of finished product at one point of the plant, the manufacturing may be carried on simultaneously at several points of the plant, the product made at different points entering into different sub-assembly products. For instance, in the manufacture of refabricated glass parts, and mercury arc rectifiers, the earliest attempts were to make each part by a given class of labor and assemble the parts by another class of labor. It was found, however, that each glass-blower had a different way of working his material, which was not subject to control or analysis by motion study. For this reason, if a certain glass-blower were to attempt to assemble parts made by another glass-blower, the amount of breakage resulting from reheating, etc., would become very great and costly. It was therefore found necessary to start in with the raw materials and let each man or group of men at a bench finish their own particular type of product, and the result was that there were several different departments on similar work, but producing different products.

The airplane industry is another example of this type of manufacturing. Material is the basis to control here.

185 *G* Yard and Repair Work. This being primarily a labor proposition, control would be according to labor, work to be done and location of the work.

186 *H* Laboratory, Technical and Secret Process. Because of the nature of this kind of work, planning methods are applicable only as blanket schedules. For instance, in the lamp industry some 25 different chemicals are used regularly by the factory, and the control of the production really means telling the head of the department involved that he must produce a certain amount of the product desired by a certain time. A similar condition exists in many chemical industries, where the entire process takes place (as in a picric acid plant) in a row of vats in the center of a shed. Here the operations are numerous and definite and require a considerable amount of supervision from the laboratory; but, on the other hand, routine is so arranged that the products are turned out continuously, and in planning only a blanket schedule of production is necessary.

187 *I* Woodworking Plants. Here the essential element to control is material, grouped according to the equipment that will perform the operations. Combinations of material on different orders will be placed on trucks and at machines, hence the necessity of controlling material, plus a progress of orders record, to know at any time where different parts of an order are.

188 *J* Structural Plants. Equipment would be the factor to control in this case, the control of material and the progress of orders to be handled the same as in the case of the woodworking plant.

189 Controlling the Control Mechanism. A problem which is frequently lost sight of is the method of determining whether or not the Control Department is producing the results that may be expected of it. It is impossible, by going into the Control Department and asking a few questions, to ascertain whether the men are really getting results, or whether they are making numerous mistakes and minimizing their difficulties. It is interesting in this connection to note that the Control Department can prepare reports

on five different subjects that will indicate improvements, or the reverse, in the work of this department:

A A graphic record of the available (or capacity) production time, the planned or scheduled production time and the actual working time, which can be expressed in machine hours, man hours or shop hours. Such a report indicates how close to the possible performance the Control Department is attempting to work, and how close to the schedules of the Control Department the plant is actually working.

B A record of the number of broken promises. If the Control Department is properly organized, all work assigned to the factory should be scheduled to be finished on a certain day, and this amounts to a promise and should be considered as such, even though no promise has actually been made to the customer. A report of this kind will show the number of promises made, the number of deliveries before the promised date, and the number of failures to meet the promises, the total amount of time by which the schedules were ahead of the promises, and the total amount of time by which the schedules were behind the promises.

C A record of idle equipment time according to class of equipment, as well as according to causes of idleness. There should also be a record of delays on the part of the workmen.

D A record of the amount of work in process in terms of value of material, as well as in terms of days' work in each department.

E A record as to the adequacy of equipment, to show what departments need more equipment and what departments could operate with less equipment.

190 These 12 points, while treated in a brief manner, will serve to indicate the important things to keep in mind when considering a scheme of Graphic Production Control. Subsequent chapters will go much further into details, but a preliminary statement of essentials will assist materially in aiding those interested in making the right start.

Section II

PRELIMINARY STEPS IN GRAPHIC PRODUCTION CONTROL

Chapter VIII

PREPARATORY STEPS IN ORGANIZING FOR GRAPHIC PRODUCTION CONTROL

191 It is not alone sufficient to decide on the installation of Graphic Production Control. The matter of a proper start is the all-important consideration. Many failures can be laid to a hasty decision to introduce better methods, with the consequent confusion, laxity, disruption and failure to secure results. In such cases it is always the plan which is condemned—never those who are responsible for the wrong beginning and therefore to blame for the failures.

192 To guard against this, 10 points are here set forth for the guidance of those contemplating the introduction of Graphic Production Control. If they are considered and followed, there need be no fear as to the outcome.

193 Ideals. There are two ideals to consider in any manufacturing business, and the first step is to ascertain to what extent the management is in sympathy with them. They are most important, as they constitute the basis of all work to be done. Briefly stated, they are these:

A The time to consider what is to be built, from the standpoint of appearance, cost, operation, and salability, is before the order is taken. This is the selling ideal.

B The time to insure the margin of profit needed to conduct a business properly is before the work of manufacturing is started in the plant. This is the manufacturing ideal.

194 Conception. When I ask what a plant manufactures, I usually receive the answer, engines, or boilers, or castings, or metal furniture, or other things. As a matter

of fact, what is made into the finished product and sold is time; and this question of time, whether that of the salesman, the department head, or the worker, is what we must keep in mind in connection with the increase of efficiency. The problem is to study those departments of a business in which time is being lost or wasted, and to build up an organization that will increase the production and reduce the costs, without in any way impairing the quality of the product. After the engineer has given the management some idea of the real ideals behind the work to be done, the correct conception of things must be put before all heads of departments in order that, with ideals and conception out of the way, the next points may be considered.

195 Status. In many plants, those in charge of the work are given no authority whatever, with the result that the ultimate achievement is not satisfactory to either the client or the engineer. I was once appointed superintendent of a certain plant, with the result that all expected me to act as any superintendent would. I was expected to hire and discharge, set rates, look after quality, follow production, take care of the discipline, and so on—the procedure customarily followed by a superintendent. As an engineer, I had entirely different ideas, which concerned a constructive policy. Naturally, the organization did not consider me a successful superintendent, since I was not performing any of the functions I was expected to perform.

In another plant I was given the title, "Assistant General Manager in Charge of Production," with the result that the organization coöperated with me to the best advantage. In a more recent case, I was given the title, "Assistant Treasurer," and this title enabled me to accomplish things that would be impossible under the usual arrangement, which does not give the outsider the right kind of status.

196 Permanent Carrying on of Work. Some competent man from the organization, or from outside, should be assigned to the engineer in charge of a reorganization as soon as possible after the work has been begun. If this is not done the client runs the risk of suffering considerable loss, for after the engineer leaves there are few in the organization who thoroughly understand the methods, or who

are in a position to carry the work on to a successful conclusion.

197 Proper Start. It is also essential that some consideration be given to the matter of the right kind of start. If work is begun in a haphazard fashion, the expected results will not be forthcoming. One, or both, of two things may be done:

A Announcement may be made to the various heads of the organization, in a letter, concerning the nature of the betterment work that is about to be undertaken.

B A meeting may be called of the heads of the departments, at which time a general talk may be given to them by the management, as well as by the engineer in charge of the work. By this plan all may be informed as to what the desires of the management are, what the work is expected to accomplish, and what the organization is expected to do by way of coöperation.

198 Views of the Management. The next step is to sound out the management of the particular company, as regards its particular views in connection with the work to be undertaken. In one plant the management wanted standards before planning, something both impractical and illogical. In another the management expected a "slam-bang" type of organization, expecting that within two or three months the increase in efficiency would be about 30 per cent. In another plant the executive changed his mind repeatedly with respect to wage-payment methods, as follows:

A In favor of the day-work plan.

B In favor of the bonus plan.

C In favor of making time studies, getting the men to attain the standards set for day wages without bonus.

D Then advocated straight piece-work.

E Believed that a classified wage plan was a good one; the foreman of the department to tell what the various men were entitled to.

F Finally concluded that the day-work plan was the best, after all.

In still another plant, the management thought it should

have planning, and after the start was made and considerable work was under way, concluded that it was too much trouble, and recommended the discontinuance of the work.

199 It is therefore well for the engineer to have a frank talk, before much is done, in regard to what the management feels should be undertaken. Such a discussion will give those in charge an opportunity to consider what factors are important and should therefore be looked into, and at the same time will enable them to combat any suggestions that might prove detrimental to the ultimate success of the work.

200 Local Conditions. A certain case that came within my personal experience will serve to illustrate the influence of local conditions. In one New England town, considerable bad feeling was caused by the organization of a club in a plant, composed of the foremen, their assistants, and such of the office workers as cared to join. A chairman and a secretary were appointed after a few meetings, and it so happened that both of the men selected were Catholics. As 20 per cent. of the foremen were North of Ireland men, you can imagine the effect in a plant that employed three thousand men. I am not a Catholic, but I was accused of being a member of the Knights of Columbus, and therefore in sympathy with the Catholics in the plant. Both the chairman and the secretary were willing to resign in order to stop the talk and agitation. I refused to accept their resignations, however, as I did not intend to be a party to a religious squabble.

201 In another city the plant superintendent with whom I was working, informed me that if I would join his club, the methods I stood for would be adopted—which was equivalent to saying that if I did not join I should meet considerable opposition. I mention these two cases as warnings, in order that you may give such attention to local conditions as will enable you to avoid any pitfalls.

202 Program. In any work of reorganization it is very necessary that a definite program be arranged as quickly as possible. In one plant, after several months of hard work on the part of the engineer, the attitude of the client was this:

A He was opposed to planning.

B He was not in sympathy with bonus.

C He would not agree to a belt department.

D He did not believe in individual job tickets.

E He would delegate no authority.

F Time-study conclusions were met with "I don't believe it."

G He did not believe in keeping track of the idle time of machines.

H He would not consider overhead or equipment time saved as an indication of the value of betterment methods. Savings on direct labor were all he considered as a guide.

I He did not feel that power costs were worth considering.

J He was opposed to spending money in the tool room.

K He was not interested in compiling costs.

As you can readily appreciate, the time of the engineer in this case was absolutely wasted, as was also the money spent by the client, all because there was no definite program to begin with. If this matter of program had been considered at the start, the engineer and the client would have parted company at the end of the first thirty days.

203 Presentation of Facts. Great care should be taken in the presentation of facts. I know of one case in which the management claimed that earnings would exceed $700,000 in one year. It was revealed, however, that it made $138,000, or less than one-fifth of the original estimate. In another plant I was informed that 50 per cent. of the orders were incorrect. Analysis revealed that only 5.6 per cent. were incorrect. In still another plant, the statement was made that the overhead was only 15 per cent. Investigation proved that in the calculations $190,000 had not been considered at all, and the overhead should have been 45 per cent. It is essential to bear down, at times, on the big things that are unearthed. By this I do not mean hitting the high spots, as is so often done in this work, but impressing the organization with the facts that are discovered. In one plant it was found that the concern

was estimating on 50 per cent. of its capacity, with the result that they were not getting anything like their share of new business, because they were working far below normal capacity, and naturally the overhead rate was excessive. In another plant we found, with respect to the sales, that 15 inquiries out of 100 resulted in orders, and that of the 85 per cent. that were lost, 80 per cent. failed to materialize on account of excessive prices. By emphasizing these two points in the different plants, we were able to convince the management and the heads of departments that there was some good in the methods we stood for, after all.

204 PLANT IDEALS. In one plant that I have in mind, a large contract was received, and the chief engineer was instructed to keep his force at work on it until the work should be finished. He objected strenuously, saying he could do better by working on the contract, stopping, and then resuming work again. The superintendent of the plant, however, was able to prove that continuous work in the engineering department would mean substantial savings in the shop. A conference was arranged for between the superintendent, the chief engineer and myself; and after a careful discussion had been held, departmental ideals gave way to the plant ideal.

With these points in mind, we can now proceed to the matter of blocking out the program necessary to the introduction of the methods contemplated.

Chapter IX

PROGRAM FOR INTRODUCING GRAPHIC PRODUCTION CONTROL

205 The introduction of Graphic Production Control is an important piece of reorganization work, involving coordination of departments, records, both cost and production, planning and standardization. The problems of adjustment are many. Steps should not be taken until they are well thought out. The peculiarities of personnel must be taken into consideration. The relationships between the various phases of the work should be carefully established. Those who will have to do with the work should be given an idea regarding what the proposed plans are, how the methods will operate and what their part of the work will be in carrying on the installation.

206 There is just as much engineering in organizing for Graphic Production Control as there is in building an engine. There must be a design first of all, the same as is made for the engine; next, the design must be reduced to paper, as drawings in the case of the engine; then the contributing factors must be put into play (machining the parts of the engine); next, the control plan must be installed (building the engine); finally, it must be operated (running the engine); all of which calls for much more serious attention than is usually given to the matter of introducing more modern methods. One of the great troubles in connection with new methods in the past is that there has been too much "hindsight" and not enough foresight.

207 To assist, therefore, in reducing the entire work to a well balanced, logical and orderly arrangement, it was considered essential to prepare a design and reduce it to

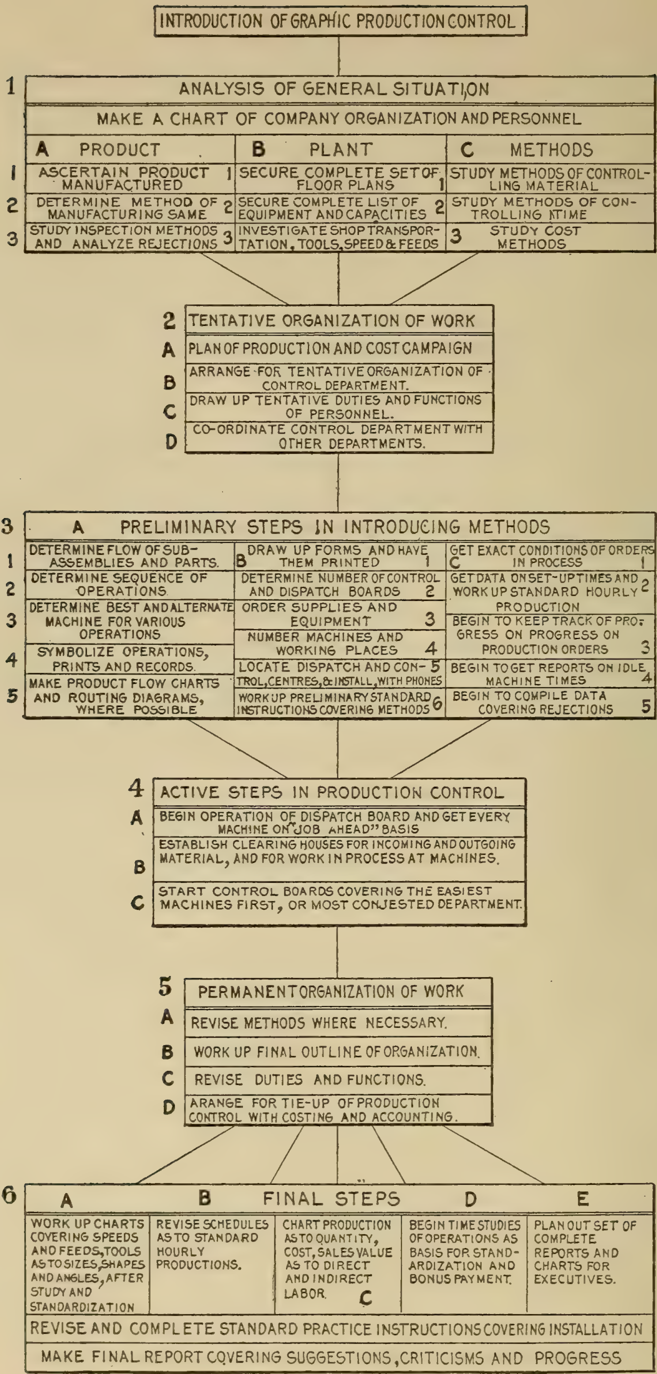


Figure 6. Steps in Introducing Graphic Production Control

specifications (Figure 6), in an effort to facilitate greatly the work of installation and operation. It is not claimed that the outline is the final word on the subject, nor that it will fit all cases. It is simply illustrative and suggestive, and as a guide will materially assist those interested in looking before they leap.

208 As will be seen, there are six divisions to the work, which can be considered as distinct phases, as follows:

A Analysis of the general situation.
B Tentative organization of work.
C Preliminary steps in introducing methods
D Active steps in production control.
E Permanent organization of work.
F Final steps.

Incidentally, it may be said that the above conforms to the author's principles of Industrial Engineering:

A	Investigation	=	Analysis of the general situation.
B	Coördination	=	Tentative organization.
C	Records	=	Preliminary steps.
D	Planning	=	Active steps.
E	Standardization	=	Permanent organization. Final steps.

209 It has been found in numerous cases that certain parts of the work can be carried on simultaneously, as in the case of divisions 1, 3, and 6, while 2, 4 and 5 are handled as units.

210 To make the presentation of the greatest possible service, it was decided to proceed on the assumption that the Graphic Production Control is in the hands of an outside firm engaged in a professional capacity, or an employee secured for this specific purpose, the firm or individual being unfamiliar with the particular case in question.

211 Taking up the six phases in their order will serve to develop the value of this plan of *predetermination* before installation.

212 Analysis of the General Situation. In this there

are four factors—the organization that will carry on the work, the product made, the plant in which the product is made and the methods in use—all of which must be studied, as they have a decided bearing on what will be done.

213 The first step is to make a chart of the type of organization as it exists at the time of starting the work. This will establish the relationship between departments. Next, enter the personnel in the proper places on the chart and you will have a "who's who" as to executives and major employees. The above should be the first work done, as it furnishes valuable data as regards how the business functions and the people you will have to deal with.

214 Breaking off from this organization study are three steps which can be carried on simultaneously, through delegation to others, and much valuable time saved.

215 As to product, it will be seen that ascertaining the nature of the product made, determining the method of manufacturing same and studying inspection and rejection records to determine the care or laxity with which the product is manufactured, will furnish an excellent idea regarding the product made. In connection with the plant, floor plans, with complete list of equipment and capacities and knowledge of shop transportation methods and of the tool situation, will give an excellent idea of the physical arrangement and of the facilities of the plant, which, with your knowledge of the product, will give you a bird's-eye view of the entire situation as regards *what* is made and *where* it is made. To complete the picture, it is necessary only to determine *how* the product is made, and a study of three things will do this: methods of material control, methods of controlling time of workers and methods of costing.

216 As can be readily seen, this has been really an investigation showing all you need to know about what *is* being done and how, as a basis for determining what *should* be done and how; so after diagnosing the findings, which will reveal weaknesses, delays, waste and inefficiency, the next step can be taken up, which is—

217 Tentative Organization of Work. In this there are four elements. Based on a knowledge of organization, personnel, product, plant and methods and supported by the

diagnosis just made, the first work is that of formulating a tentative plan covering the production and cost campaign. I say "production and cost" advisedly because they cannot be divorced if you want the maximum attainment from your installation. There is no such thing as a production scheme wholly independent of the costing, nor a cost system that in no way ties in with the production plan.

218 In blocking out this tentative plan, attention should be given to labor control, equipment control, operations control and material control, which, as outlined in the previous chapter, are the elements in production control. How production is to be controlled and costs collected and compiled must be decided upon in connection with the work of planning out the campaign.

219 You will now have a tentative program of the methods to be installed, and this will determine the type of Control Department to be organized, as well as the personnel necessary to carry on the work, after which a tentative draft of duties and functions of Control Department personnel should be made, which will furnish an idea as to the scope of the work and assist in the matter of selecting a suitable Control Department force.

220 Having a plan with tentative organization of Control Department along with duties of personnel, and studying the chart as to type of organization and personnel, as developed in the first step, efforts can be directed toward coördinating the Control Department with the other departments, which will exert no little influence in bettering and strengthening the organization from the top down; and when you get through, you will have gone a long way toward effecting a logical reorganization.

221 So far the diagnosis has been made and the remedy prescribed. Troubles and correctives have been established. Taking the medicine is the next step, so we arrange for—

222 THE PRELIMINARY STEPS IN INTRODUCING METHODS. Here there is a threefold program, the work of all three to be carried on simultaneously. In this we must secure more information regarding the product than we were able to ascertain at the first step; we must develop the new methods more in detail and get the mechanism installed, and we must

take steps to become sufficiently acquainted with actual manufacturing so as to fit the new methods to the requirements without interfering with production or causing any confusion.

To know the routes traveled by the product, we must know the flow of sub-assemblies and parts; to know what work is to be performed and the order of manufacture, we must know the operations and their sequence; to know what class of labor is necessary for prescribed operations, there must be a labor analysis; to know where work is performed, we require a knowledge of best and alternate machines for the various operations; to facilitate the clerical work, symbolizing and numbering must be done wherever necessary; and as an assistance to the entire work, product-flow charts and routing diagrams will be found unusually helpful.

223 While all this is being done, forms are being drawn up and printed; the number of dispatch boards and control boards have been determined; supplies and equipment have been ordered; machines and working spaces have been numbered; the dispatch and control boards have been installed with telephones, and preliminary standard practice instructions have been drawn up not only for the Control Department force, but for the guidance of those whose work will be influenced by the new methods.

224 Another campaign has been under way all the time, which fits in well with the other two elements. By getting the condition of orders in progress and keeping such a record up to date, we have an inventory of work ahead which can be taken over by control mechanism at the opportune time. Estimated standard hourly productions, and set-up times, if the class of work justifies it, are being compiled—an important piece of work, indeed, as it forms the real foundation of Graphic Production Control, as will be shown later. Progress is being watched as to production orders; idle-time data are being compiled and rejections are being noted, all three steps being of the utmost importance in switching from the old methods to the new.

225 We are now in possession of the necessary data regarding the details of the product; the methods have been developed, forms printed, mechanisms installed and instruc-

tions issued; we have been keeping pace with the manufacturing, as it has been carried on from day to day,—running alongside of it, as it were, the same as in a relay race. The other runner is ready to drop out of the race while we go on with it, which makes necessary—

226 THE ACTIVE STEPS IN PRODUCTION CONTROL. With dispatch boards installed, forms ready and a knowledge of orders, idle time and rejections, we arrange to get machines and men or gangs on these boards through time tickets covering direct and indirect labor and idle time, and, as a result, *we have a real control of labor.* Then because of our knowledge of the material situation through material requisitions, move orders, identification tags and defective reports, we are ready to establish clearing houses or stopping points for material, as the basis for facilitating the movement and handling of material, covering incoming and outgoing and work in process materials, *which gives a real control of material.*

227 In possession of real information as to labor and material and knowing what is going on in the plant and the condition of orders, we are now ready to swing the entire proposition to the control boards, which, picturing the plant or department in miniature and showing congestion of equipment, as well as overequipment, also the ebb and flow of work and the condition of materials, gives us the basis for manipulating the production activities to better advantage, and consequently *gives us the control of the plant or department.*

228 The machinery of planning, routing and scheduling is now running; through the control of labor, equipment and material, we are in possession of complete information regarding what is made, when, how and where. We can now stand off and view the entire thing in perspective and form true conceptions of the strength and weakness of the component parts, as a basis for betterments and refinements, paralleling the engine on the test block, which logically leads us to the next step—

229 PERMANENT ORGANIZATION OF WORK. Certain weaknesses will develop in the methods, the same as they will develop in the engine on the test block, so revisions must

be made where necessary. Some of the departments under the rearrangement will fail to function properly, so a final outline of organization, based on the later information, will have to be made. The changes in methods and in the organization will make necessary the revision of duties and functions of departments and personnel, and, as a final adjustment, the production and cost methods must be tied in and coördinated with the accounting methods, all of which will enable us to get the whole proposition running more smoothly, so that, like the engine after the necessary changes, it will pass the test and be declared "O.K."

230 With the installation running along smoothly, with products under control and the control methods tied into the cost and accounting methods, the finishing touches or refinements are all that are necessary to complete the installation, which leads us to—

231 The Final Steps. In this there are five more or less simultaneous steps which have no particular reference to each other, but which are nevertheless important and necessary. There is the work of standardizing the speeds and feeds, tools as to sizes, shapes and angles, and the jig and fixture and small tool equipment. Reductions are being made in operation times which increase the standard hourly productions, and these must be recorded and used in the current practice. There should be charts made showing the results of the installation, covering productions, labor costs, idle time, rejections and the like. A time-study campaign can now be undertaken, if desired, as the basis for standardization of operations and for rewarding workers in proportion to individual attainment. There should be worked out, as a result of compiling all the available information, charts giving a graphic presentation of manufacturing statistics for the plant executives, as their guide in directing things more efficiently.

232 These five programs can be carried on together, separately or in combination. The question may of course be raised, Why not do these things before the active steps are undertaken (fourth step)? This was answered to a degree in the seventh chapter in the section, "The Start." I would rather have control of my labor, material and equip-

ment, even if they were not operating at highest efficiency, than to have all kinds of standardization, with my plant operating at 50% of the possible efficiency, due to the confusion, delays, idleness and waste which go with lack of control. At any rate, our own experience, and this must be the best teacher, indicates the plan outlined to give the most results in the shortest possible time.

233 These five elements having been considered, we can now take up the two final campaigns: (1) revising and completing standard practice instructions covering the entire installation, including all changes of whatever nature, bringing everything up to date for reference purposes, which should be presented in both written and graphic form; (2) then comes the final report as to conditions found at the start, steps taken, efficiency of the installation, results attained, suggestions and criticisms which may seem necessary, and any other pertinent information which the company should have.

234 This résumé of the steps necessary in introducing Graphic Production Control, although rapid-fire in nature, will serve to indicate the extreme importance of a skeleton outline, as it not only furnishes an objective, but enables us to study relationships, scope, complications, coördination and the general organization of the work, and is submitted with the suggestion that any contemplated changes of importance be reduced to program and plan before a start is made, which will make for more successes and fewer failures.

Chapter X

ANALYSIS OF THE GENERAL SITUATION

235 The organizer, whether he is from the outside or on the payroll of the company, must become familiar with the business from A to Z. I do not mean by this that he must be familiar with all of the actual practice and the details of the business, but he must be able to read the business like an open book.

236 There is much more to this matter of analysis than most people think; or, to put it another way, few people know how to investigate. We are very apt to be careless regarding details, and to overlook much that is pertinent. For instance, I will defy a man to answer offhand all of the following questions:

A How many buttons on your vest?

B How many stairs lead from the first floor of your house to the second floor?

C How many windows in your office?

D Is the figure 6 at the bottom or top of your watch?

237 Here are a few excellent tests of observation and perception, which will perhaps better indicate just what I mean:

Examine a machine you are unfamiliar with, determine its purpose, and understand its parts and relations. When you have analyzed for a sufficient length of time, close your eyes and mentally take it to pieces, and then put the parts together again.

Gaze steadily at a man working on an unfamiliar operation. Keep your mind on the object with intentness. Close your eyes and, after consideration, write out all the details in connection with what you observed.

Sit quietly and exclude all thoughts from your mind, and then consider an operation you are familiar with, to the exclusion of everything else. How long can you do it?

Gaze straight in front of you, with every power of attention alert, and, without turning your eyes, observe as many things as you can within the immediate range of vision, while counting ten slowly. Write what you saw without again looking, and then check the results.

238 I have mentioned these problems simply to indicate that the human brain, unless trained, is not the power that we generally imagine. The question is, How can we assist it?

239 To aid those interested in this great subject of Graphic Production Control in making an investigation of the general manufacturing situation as it pertains to organization, records, planning, standardization and relations, the following questionnaires are submitted simply as guides; for while many of the questions may not cover the business under investigation, numerous others will suggest themselves, with the result that the business will be pretty well covered from the standpoint of the proper questions.

240 QUESTIONNAIRE ON ORGANIZATION.

1 In which of the following ways is your business divided into departments or divisions?

a In accordance with functions?

b In accordance with products?

c Through accidental groupings?

d Through the gradual growth of individual responsibility?

e In accordance with the physical arrangement of the plant?

f In accordance with the geographical location of the plants or offices?

g Any combination of the above or other factors?

2 If your organization is divided in accordance with functions, what are the divisions and what functions independent of each other in authority and responsibility do they represent?

3 Do these divisions represent an effort to divide your business intelligently into those sections under which it can be most competently managed with the least managerial effort?

4 Which of the above divisions of your business report direct to the chief executive?

5 Do the departments under the chief executive report to and receive instructions only from him, or are there others who are empowered to give them instructions?

6 Do the various divisions of each department report direct to the departmental head or does the chief executive often instruct them direct?

7 Does the head of each department control all factors affecting the successful accomplishment of his function or are there many factors not under his control, or is he obliged to split his authority with others?

8 Have the heads of departments any say concerning the order, production, or cost system, repair methods, or any factor directly affecting the accomplishment of their own and other departments?

9 Are there any committees composed of the departments interested, organized for the specific purpose of considering these questions; and if not, how are they adjusted?

10 Has the chief executive any staff or employees under him whose sole duty is the study of unsatisfactory interdepartmental systems or unsatisfactory conditions in individual departments? If not, what is the method of remedying such conditions?

11 Do you find it possible to permit your sub-executives to make their own decisions as to their departmental policies, or is it necessary for you to approve all such plans and decisions?

12 Can sub-executives make expenditures for improvements in their departments without your approval? If so, within what limits?

13 Can a sub-executive employ additional help for his department without your approval?

14 Can a sub-executive purchase equipment or machinery for his department without your approval?

15 Do you have charts of organization showing the

course of authority and the relationship between departments?

16 Have you any written statement definitely defining the duties and responsibilities of your various executives and departmental heads, or do you depend on oral instructions?

17 Is your business divided into departments or divisions in such a way that the various positions can be competently filled by average men, or is it divided in such a way that extraordinary men are required?

18 Have you ever attempted to arrange the duties of your various positions so that they could be competently conducted by the average type of man who could be hired to fill the position?

19 Is your organization so arranged that the knowledge required by your various departmental heads for the performance of their functions is sufficiently restricted to permit them to become specialists?

20 Do you have difficulty in procuring executives and employees competent to fill satisfactorily your various positions as they are now arranged?

21 Do you carefully analyze the characteristics necessary in a man for the competent filling of your various executive positions and do you measure the men selected against these requirements?

22 Are your present executives men selected from your own organization, or were outsiders brought in to fill these positions?

23 Are your sub-executives independent or are they leaners depending on their superiors for guidance in all their decisions?

24 Have you provided understudies for all important positions? If any executive leaves, is there some one in the organization who can competently fill his position?

25 How do you judge your executives or departmental heads: by the proven results of their section of the business, or by little things which you happen to notice are wrong?

26 Do you consider that you have sufficient data to judge fairly the accomplishments and ability of your various executives?

27 Have you noticed any antagonism or friction between executives, or any tendency to form political factions?

28 Do you consider such animosity personal or is it due to the faculty relations under which your executives are forced to work?

29 Is the general attitude of your executives one of contentment and energetic accomplishment or one of worry, dissatisfaction and indifference?

30 Do your executives express their opinions to you freely and with conviction, or is their attitude apologetic, or do they attempt to excuse their faults and court favor with you?

31 Do you find that executives brought into your organization develop beyond your expectation, or that they seldom ever live up to their recommendations? In other words, is your organization a man-builder or a developer of leaners?

32 After a consideration of all the above, do you find that your organization meets with your ideals as to organization?

33 What are your ideals as to organization?

241 Questionnaire on Records.

Adequate records, both for basis of operation and for history, are more and more being admitted to be indispensable. Their volume is such that memory fails under the load, and records only can support judgment.

1 Have you a complete record of your product, properly catalogued?

2 Is every assembled part recorded as to its component sub-assembled parts?

3 Is every sub-assembled part recorded as to its individual component parts?

4 Is there a record of the sales of each individual or assembled product?

5 Is there a record of the proper raw material to use in manufacturing each individual part?

6 Is there a complete record of the machine operations necessary to manufacture each individual part?

7 Is there a record of the time required and the best and alternate machine on which to perform the operations specified in No. 6?

8 Have you adequate stock records of all stock material, consisting of raw supply, individual manufactured parts, partly assembled and fully assembled parts, etc., showing:

a Location (in stock room).

b Quantity required (for assembly or shipment).

c Quantity ordered (outside or in plant).

d Quantity received (by purchase or manufacture).

e Quantity issued (for assembly or shipment).

f Value in money of material received.

g Value in money of material issued.

h Maximum and minimum stock.

i Economical amount to order.

j Time required to procure (either through plant or purchase).

k Quantity used in past years.

9 Is a requisition required for any and all material of whatever kind used?

10 Are these requisitions recorded in stock records?

11 Are these requisitions priced properly?

12 Are records made of the total value of all materials consumed for each month?

13 Does your ledger have controlling accounts showing controlling totals for—

a Each stock room?

b Work in process, properly divided by departments?

c Burdens by departments?

14 Is all work in factory controlled?

a Productive, by productive orders?

b Burdens, by expense orders?

15 Is every dollar of your payroll accounted for by a job time record?

16 Do you make up your payrolls from your job time records, or from clock cards?

17 If from clock cards, how do you prove up your job time as reported on job cards with the actual money paid out?

18 Do you know every month exactly the burden for each operating department?

19 Do you use actual or predetermined burdens in figuring costs?

20 If you have detailed records of operations required —and time for each—to produce parts, do you—

a Record work ahead for machines?
b Record work ahead for assemblers?
c Use graphic control record for machines?
d Use control card record for machines?
e Use dispatch boards and clerks?
f Record progress on all production orders?

21 Do you purchase goods with the backing of absolutely reliable records?

22 Do you charge all purchases of either stock material, labor or expense items to a series of intelligent and useful control accounts?

23 Do you account for the use of all material, labor and expense as carefully as you do your cash?

24 Do you so account for every dollar that *some one* has to answer for its disposition?

25 Do you finally succeed in securing from your records a trustworthy statement of profit and loss each month?

242 Questionnaire on Production Control.

Are your products delivered to your customers on the dates promised, or are your deliveries liable to be late? Also, are you satisfied with your volume of production?

If troubled with late deliveries or lack of volume, set down at first, before going further, the reason uppermost in your mind as accounting for the delays. It will make this questionnaire doubly interesting to do this, and then, after going through the balance of the questions, see how your opinion will compare with the one you held at the start.

1 Have you a specific department devoted to the planning of work through your plant?

2 Is the work of design so scheduled as to be completed in time for the purchase of materials in accordance with

the time necessary for purchasing and manufacturing in order to meet certain specific delivery dates?

3 Are you afterward interfered with, due to changes in designs, by either—

a Your own Engineering Department?
b Your customer's Engineering Department?

4 Do you have complete bills of material or specifications of all parts which enter into your assembled products?

5 If you have such complete specifications, have you also sub-specifications covering the exact procedure in your shops, such as part assemblies put up and stocked, to appear again either in direct shipments or in further assembly?

6 Have you any definite means of planning just when purchased materials will be required in process?

7 Have you any definite method of notifying the Purchasing Department of material needs, sufficiently in advance of requirements to allow ample time to purchase same and have them delivered when required?

8 Do purchase orders state when goods must be delivered, and how are promises of delivery secured consistent with the delivery required?

9 Is your plant frequently held up from overdue purchased materials?

10 Are there delays from shortages of regular stock material in your plant?

11 You have materials, from raw to finished goods, on hand; have you segregated and organized stock rooms and storekeeper control for—

a Raw materials and supplies?
b Manufactured parts and partly assembled parts?
c Finished stock ready for shipment?

12 Have you adequate stock records covering stock materials of all kinds?

13 Do such stock records or stock rooms provide for the reservation of materials for certain specific orders?

14 Is the production of your plant under the control of an adequate production order system?

15 Do you get adequate records of the production by men and machines by quantities daily?

16 How long does it take to get a customer's order disposed of into the necessary plant routine?

17 What is the ratio of the value of your total work in process to a month's completed production?

18 Are you sure that your machine tool and other equipment is in proper balance?

19 Are your machine tools arranged for proper flow of materials?

20 What operations cause you the most trouble or delay?

21 Are you sure such machine delays are not on account of inefficient use of the machines?

22 Do you make sufficient use of jigs, templates and like devices?

23 Do you make a study of getting all possible work on a machine at one set-up?

24 Do your machine operators handle material to and from their machines to the detriment of machine production?

25 Do your machine operators grind their own tools?

26 Do you have a special and competent tooling expert?

27 Do you have any specific place for work ahead for each machine?

28 Do you always have work ahead for each machine?

29 Do you always have jigs, fixtures and tools all ready and waiting for each new job, without any delay?

30 Do all lots of material in process have proper identification cards or sheets with them?

31 Do you maintain a record of the progress by each operation of each lot of material?

32 Do you maintain any record of the operations necessary to produce any and every piece?

33 Do you maintain a record of any kind to show the schedule of work ahead of each machine tool; and if so, as to whether or not the schedule is being lived up to?

34 Do you always plan the most economical size of run for each machine operation?

35 Are your machine runs often broken into by rush jobs or other causes?

36 If your product is largely made up of assembly parts—

a Is the daily production of each assembled product uniform, or does it fluctuate widely from day to day?

b If it fluctuates, is it due to the erratic flow of parts to the Assembly Department?

c Are all individual parts passed through a stock room before going to the assemblers?

d Are parts brought to the assemblers, or do they get their own?

e Are there any semi-completed assemblies on benches or floor waiting for parts?

f Do you have any method of making sure that all parts necessary for assembly are on hand before the assembly is started?

37 On what do you base your promises of delivery to customers?

38 What proportion of promises are kept?

39 After the foregoing questions are all answered, and you have carefully surveyed your whole manufacturing proposition, how does your opinion compare with the one held at the start?

243 Questionnaire on Standardization.

1 Have you set standards of quality for all raw materials purchased, and supplied standard specifications to the Purchasing Agent?

2 Have the standards been set through careful tests and experiments so that you are sure that—

a The materials are not of such a low quality as to increase the production expense to more than offset the saving in price, or to interfere with the utility and reputation of your product?

b The materials are not of a needlessly high grade, causing additional expense without a corresponding decrease in manufacturing cost or additional profit?

3 Are all incoming materials tested in comparison with your standards?

4 Have you standardized your supplies, or is each department allowed to indulge its individual preference? Do you use the same typewriters, carbon paper, etc., in all departments?

5 Have you set standard qualities for supplies? Is the grade of paper used in forms the cheapest consistent with the purpose for which it is used? Are the pencils the cheapest grade which will give satisfaction?

6 Have you standardized the stock parts used on products so that—

a Standard screws, bolts, nuts, pins, etc., are used, thus reducing the quantities and varieties of stock carried, or the varieties to be manufactured?

b Parts are interchangeable?

7 Have you standardized your products to meet all requirements of the trade with the least possible number of varieties to be manufactured?

8 If your work is that of cutting metals—

a Have you standardized the shapes and angles of all cutting tools, or is the workman allowed to grind and shape his own tools?

b Have you standardized the cutting speeds to be used for various feeds and cuts for all grades of metal handled?

c Are the workmen supplied with charts from which they can obtain the proper speeds, or are instructions as to proper speeds issued with the work order?

d Have you standard charts for each machine, showing the speeds that will be obtained on various sizes of work for each setting of the machine?

9 Have you studied and standardized the speeds of machines, so that they run at the speed which produces the greatest quantity of work of satisfactory quality?

10 Have you analyzed all operations, and provided the facilities and the arrangement of work which enable the operator to obtain the greatest speed of production?

11 Have you analyzed all operations and eliminated production and time lost due to the workman getting material,

hunting up work, adjusting his machine, and other items causing a loss of production?

12 Have you set production standards for your various operations with which the actual production can be compared?

13 Have you set standards by which the accomplishment of your various departments can be fairly and accurately judged?

14 Have you determined and standardized the exact duties to be performed by each executive member of your organization? If so, has each executive and sub-executive a statement in written or graphic form explaining his duties, authority, and responsibilities?

15 Have you set standard cost figures for all products against which actual costs may be compared?

16 Have you set standards as to the quantity of work to be carried in process to keep your plant operating smoothly without excess investment in material in process?

17 Do you sell what you can best make, or make anything you can sell, or have you no standard policy?

18 Do you make a standard product or products, or do a jobbing business, or is your business a mixture of both without a definite policy?

19 Are your sales based on quality or price, or do you merely follow competition without a standard policy?

20 Do you manufacture parts for stock and assemble on orders, manufacture for and sell from stock, manufacture for orders only, or do you follow the line of least resistance, without a standard policy?

244 Questionnaire on Industrial Relations and Incentives.

1 What is your percentage of labor turnover? To calculate same, determine the number of employees hired and the number of those who left or were discharged during the year, and divide the lowest figure by the average number of employees on the payroll during the year. The average on the payroll can best be obtained by adding the twelve figures representing the number on the payroll at the end of each month of the year and dividing by twelve.

2 Is your plant union or non-union?

3 How do the wages you pay compare with the local labor rates and the union scale?

4 How many hours are your employees required to work, both in the plant and in the office?

5 If the greater part of your labor turnover is due to men leaving of their own accord, in spite of good wages and moderate hours, to which of the following reasons would you ascribe their dissatisfaction with their work?

a Improper methods of training new men?

b Foremen or instructors who habitually find fault with and discourage men, or who are cranky and disagreeable?

c Poor tools or equipment which it is difficult to work with?

d Annoying interruptions to work, or difficulty in obtaining materials, tools, instructions and other working facilities?

e Poor working surroundings or sanitary and safety conditions?

f Lack of such living conditions or social relations as create a liking for the community in which the plant is located?

g Lack of recognition of good work?

6 If the greater part of your labor turnover is due to the discharge of men—

a Is it because you fail to select men suitable for your work, or that you fail to place them at work best suited to their ability?

b Is it because your foremen are irascible and discharge men who are competent but with whom they clash personally?

c Is it because when men are unsatisfactory to one foreman, you make no attempt to find other work in your plant which they can handle satisfactorily?

7 Do you interview men and carefully inquire into the reasons why they are leaving or were discharged, and do you classify these reasons and take action to eliminate some of the causes of your turnover?

8 Do you keep adequate records of the accomplishment and progress of your employees, and do you stimulate their ambition and enthusiasm by compensating and promoting them fairly in accordance with the value of their services?

9 What have been your past labor troubles, and how were they settled?

10 Have you a safety committee, or other means of taking action to provide safe and healthful working conditions?

11 Have you a welfare department, and do you interest yourself in providing first-aid rooms, medical advice, good housing and transportation facilities, eating facilities, special activities, benefit plans, and locker and wash-room facilities for employees?

12 Have you provided definitely for the proper training of new employees, and do you provide any means of education for those who desire to advance themselves through extra work?

13 Is your organization of executives and sub-executives harmonious and coöperative, or is there evidence of friction, factions and plant politics?

14 Have you noticed any tendency among your subordinates to avoid censure by "passing the buck," or to complain of and run down others in the organization?

15 Is it your policy and that of your executives to obtain results by censuring and driving your employees, or by praising, rewarding and encouraging them? Is the motive-power of your organization fear or enthusiasm?

16 How do you obtain your opinion as to the value of your various executives,—through definite figures indicating results, or through various things which you notice are right or wrong?

17 Have you any bonus systems or standard advancement systems by which executives are fairly rewarded in proportion to the results they obtain?

18 Do you advance men from your own organization to fill executive positions, or do you fill such positions with outsiders?

19 Are your employees paid on day rate, piece rate,

bonus, premium, or profit-sharing system, or on any combination of the above?

20 If several systems are in use, what is the proportion of each?

21 Are your men working energetically, or do they seem to be limiting their production?

22 Do the earnings of various men on piece rates or bonuses approximate the same amounts, or do they vary widely?

23 How are rates set,—by estimation, past performances or time study?

24 Do you study and perfect your operation before setting rates?

25 Do you give consideration to fatigue in setting your rates?

26 Have rates ever been cut? If so, what were your reasons?

27 Do you pay bonuses for the quality of the work, or do you deduct wages for spoiled work?

28 Do you have to give day-rate allowances on piece rates? If so, what proportion of your piece-workers receive such an allowance, and what is the weekly cost?

29 What additional wages are allowed for overtime work?

30 What proportion of your employees work overtime, and what are their weekly overtime earnings?

31 Do you feel satisfied that you are taking all means in your power to obtain the hearty good-will, enthusiasm and coöperation of your employees?

245 Having covered the matter of organization, records, planning, standardization, and relations in a comprehensive manner, the next step is to take the findings, carefully analyze them, and, after due thought, prepare an outline of the faults found. A suggested outline is contained in the sixth chapter, in which conditions are set forth indicating beyond any question the entire absence of any control of production.

246 Based on a knowledge of weaknesses and inefficiencies resulting from the diagnosis, an outline of "Construc-

tive Recommendations" should be made as the first step toward a tentative organization of the work contemplated. The one which follows, taken from actual practice, in the case of an automobile factory, is merely suggestive in character.

247 CONSTRUCTIVE RECOMMENDATIONS. A brief outline of our recommendations, which we feel necessary to overcome the faults that we have found, can be classified under the following heads:

A Management.
B Sales Department.
C Engineering Department.
D Purchasing Department.
E Stores Department.
F Receiving Department.
G Manufacturing Department.

248 *A* MANAGEMENT.

a The management should make all decisions with reference to the design of all new models, sufficiently in advance to allow such departments as Engineering, Purchasing and Tool ample time to complete their part of the work by the time the actual manufacture of the model begins. This should be done in accordance with a definite schedule of times for decisions on various parts or models as worked out by the Engineering Department.

b The management should make out a definite schedule of the quantities of each model to be produced in a given time, sufficiently in advance to allow all departments ample time to prepare their work. These schedules should be changed only at predetermined periods; and the longer these periods can be made, the more economically the plant can be operated. In one instance of successful manufacture of automobiles, models are changed only once every three years, designs twice each year.

c There should be no change in the designs of cars or parts in process, excepting in cases where serious error in design, if unchanged, would impair the reputation of the company.

249 *B* Sales Department.

a The Sales Department should sell no cars in which the chassis varies from the standard models determined upon until the demand is such that the changes can be made standard or the creation of a new model warranted.

b The Sales Department should submit to the management twice each year their ideas with reference to changes in the designs; it being understood, of course, that they shall be submitted well in advance of the time scheduled for manufacture.

250 *C* Engineering Department.

a The Engineering Department should calculate, through the methods herein outlined, the times various operations should start in order to turn out new models on a certain date. They should furnish the management with an idea of the times final decisions must be made. They should submit to the Purchasing Department times covering purchases, and determine the time of starting and finishing all designs, experimental models, jigs and fixtures, as well as the start of the various shop operations, all of which, as you can readily appreciate, ties the Engineering Department to the control arrangement in an efficient manner.

b They should work up a list of all parts used in all assemblies on all models, and maintain the same, supplying each assembly division with a list of the parts and the part numbers used in the various assemblies.

c They should also maintain a list of all parts according to the class of material from which they are made, and should calculate from this, depending upon the schedule of the number of cars to be made, the amount of each kind of material or purchased part needed. They should supply these to the Purchasing Department in sufficient time to allow for the purchase of this material well in advance of starting manufacturing. This calculation should be made for every type of material used, including nuts, bolts, accessories, upholstery, etc., which, if done, will eliminate much in the way of guesswork and inaccuracy that is at present a detrimental feature.

d The Engineering Department should get out drawings and prints in accordance with their schedule, allowing ample time before manufacturing begins.

e The Engineering Department should plan, schedule and build the experimental models so as to have same completed sufficiently in advance of the start of manufacture, in order that the errors shown by the experimental work may be corrected before regular production begins.

251 *D* Purchasing Department.

a The Purchasing Department should be supplied with definite information as to the quantities of the materials to be furnished by the Engineering Department, and should be relieved of the present necessity of estimating with reference to the amounts to be purchased, after verbal conferences with the management.

b The Purchasing Department should work up a list of all types of purchased parts, showing the time necessary to purchase same. They should keep this list up to date by making such changes in the time as are necessary when these changes occur. This list should be supplied to the Engineering Department as an assistance in making up its schedule. The elements to be considered in determining these times are:

1 Time necessary to get prices.
2 Time necessary for the vendor to manufacture.
3 Time necessary for transportation.
4 Time allowance for internal handling in the plant.

c The present follow-up system—which consists of periodically going over the purchases, and which is more costly than it should be and does not get maximum results—should be discarded and replaced by a regular system of graphic follow-up on the various items of orders, in such a manner as to list only the exceptions which must be looked up.

d It will be necessary for the Purchasing Department to study the deliveries of the firms from whom large purchases are made, in order to make certain that these firms have the capacity to build and meet the delivery dates and

amounts required. We have a proposition at present before one of the largest automobile concerns in the country, in which we propose graphic methods in their plant covering the plants they purchase from, which would enable this plant to anticipate failure to deliver on time long before it is now discovered by the Purchasing Department. We suggest such an arrangement in your case.

252 *E* Stores Department.

a The Assembly Stores Department should be either relieved of their present duty of ordering small parts at the beginning of the year, or should be informed of the exact quantities required by the Engineering Department. If relieved of this ordering, it should supply the Engineering Department, on request, with an inventory of the parts on hand and the number scheduled to be used for the remainder of the year, so that in case of an excess remaining, the Engineering Department can decrease the amounts it requisitions from the Purchasing Department.

b The Stores Department should keep a graphic record of the various assemblies made and of the parts received for use in these assemblies; and when the number of parts ahead reaches a minimum, should notify the Purchasing Department of this fact.

253 *F* Receiving Department.

a The Receiving Department should be supplied with competent material inspectors, and all goods received should be inspected as to quality, in conformance with specifications.

b As there is evidence of neglect to count or weigh goods received, the Receiving Department's copies of orders should have quantities left off. This makes it necessary for the Receiving Department actually to count and weigh materials, which are then checked by the Purchasing Department against the quantities ordered.

254 *G* Manufacturing Department.

a This department—the name of which we would advise changing to "Control Department"—should schedule

the starting dates for the manufacture of all parts, at the beginning of the year, in accordance with the schedule submitted to it by the Engineering Department, in order to insure a uniform flow of parts to the Assembly Departments.

b It should substitute for the follow-up plan now used, a graphic sheet as outlined in "Methods Proposed," which record would keep track of the production by operations.

c When work falls behind in any of the departments, as shown by the schedule given them from the graphic sheets, they are immediately to notify the Control Department of the fact on shortage slips, giving the reason for the delay and what they will have to do to make the schedule.

d Graphic machine control boards should be installed and work should be planned well in advance covering all machines. Jobs would be scheduled to the departments as shown by these boards. Small strips of paper corresponding to the length of time a job or operation will take are placed on this board in metal slides. On these slips are entered the order number, if any, the kind wanted, and the operation. A vertical string or plumb line is used in connection and is moved forward from day to day, so that a glance to the right of the string will show at all times the work ahead on each machine, while a glance to the left will show the work behind the schedule. Further, these will show the gaps or unused capacity between operations, as well as where congestion exists.

e When operations fall behind schedule, departments will be required to work their machines overtime until the work is caught up and the schedule arranged for.

255 The investigation, diagnosis and outline of constructive recommendations will be found an excellent means for determining what should be done looking toward the installing of Graphic Production Control.

Section III

INSTALLATION OF GRAPHIC PRODUCTION CONTROL

Chapter XI

TENTATIVE ORGANIZATION OF WORK

256 The task now confronting us is to organize tentatively our work of Graphic Production Control, based on the investigation made of conditions, the diagnosis, and the outline of constructive recommendations, as discussed in the previous chapter.

257 The first law of organization is that of the objective, or determining the ideal we desire to strive to attain. The ultimate or final objective cannot be agreed upon at the start, owing to the presence of unknown factors and variables which cannot be determined upon in advance; in fact, it will be well toward the completion of the work, as previously pointed out, before the final plan can be decided upon. Hence a preliminary outline is necessary at the start.

258 To define our *objective,* let me make a presentation of "aims and purposes." Manufacturing from the standpoint of modern management is getting to be more and more complex, and despite the rapid strides and refinements made in the last twenty years, the cost of living keeps increasing. Increases in wages and fewer hours seem to be the order of things, until we are rapidly approaching a condition which may become unbearable, and which will affect both worker and employer alike, unless there is a change for the better. The attitude of both the worker and the employer seems to be that of "give as little as possible and get as much as possible," and the chief sufferer is the dear public, of which all of us are a part. To eliminate industrial clashes and strikes, to reduce the cost of living, and to take our place in competition with the other nations of the globe, certain things are necessary, *and*

they are not less hours and increased wages. Study reveals them to be—

259 *A* EQUIVALENCY. Determining what is a fair hour's work for different operations in industry, that men and equipment can turn out without injury to health and well-being of men or detriment to equipment, is what is meant by equivalency. This, to the author's mind, is an economic fundamental; for if we can secure equivalency, we need not concern ourselves so much about the matter of wages or hours of labor. It is altogether a matter of securing production, utilizing every facility that can be invented, and every method that can be devised, toward getting out a maximum, or quantity, production. The greater the production, the less the cost; and the less the cost, the greater the demand. Hence in industry, standard hourly productions should be determined, against which should be measured the actual attainments to determine the ratio of efficiency.

260 *B* KNOWLEDGE OF COSTS. The complexity of industry; the intricate tax laws and the importance of correct returns as to incomes; the intense industrial competition that is coming, and the inability to say what can or cannot be done in the way of increasing wages or arranging for profit-sharing, along with our notorious inefficiency from a cost-keeping standpoint, which associations of manufacturers are beginning to recognize, should convince the most skeptical as regards the absolute need for modern and uniform cost-keeping methods.

261 *C* ELIMINATION OF IDLENESS. Idleness, whether in materials, floor space, or equipment, or on the part of workers or executives, is being recognized more and more as a severe drain on our resources, and yet there is more of it in industry than the average man realizes, which idleness is included in the prices we pay for things. I have no right to expect interest on hoarded or idle money, nor should I have a right, in industry, to interest on money which produces nothing. *Idleness to-day is rewarded,*—not to the same extent as thrift, but it is paid for nevertheless. If I can get prices for the products of my plant, which are made by one-half the capacity of my plant, the

charges covering the idle half going into my overhead or burden account, then the public is paying for this economic waste, *as well as a profit on it.* Hence one of the most practical ideals of Graphic Production Control is the elimination of idleness of whatever nature, or at least its reduction to a minimum.

262 *D* EFFICIENCY. Even with the elimination of idleness—floor space, equipment, and materials may be used inefficiently, and men may work inefficiently. There should therefore be constant striving to reduce waste and lost motion through standardization, incentives, better relations, better conditions and the like. Efficiency can be measured if there is equivalency, or the expression of performance in terms of standard attainments.

263 *E* REJECTIONS. Defective and spoiled work makes for high cost, and as a form of waste should be eliminated in so far as is possible, and this feature should be analyzed and studied as carefully as idleness.

264 *F* SELECTION OF WORK. No man should do any work that can be performed as well by another with less skill and at less expense, or with greater skill and more expert attention. The machinist should not move castings from the stock room, as this can be done by a laborer, nor should he grind his own tools, as this should be done by an expert. Further, work should be assigned to men best fitted to do it, and not given out because they have nothing else to do.

265 *G* METHODS TO SERVE BUSINESS AS A WHOLE. A Graphic Production Control plan, to be of the greatest possible value to a business, must serve the three principal divisions, namely, Selling, Production and Financial.

266 *H* ANALYSIS OF WORK BEFORE STARTING. In most plants, an order taken at a close margin is watched, coaxed and nursed along in the plant, with the result that a profit is made, or the loss kept to small proportions. Because it is definitely known what must be done, close supervision sees that it is done. *Why not follow the same procedure as to all orders?* Therefore, the time to see to it that a profit will be made or the loss kept to a minimum, is certainly not when the work is partially finished or entirely completed,

but before it is put into the plant for starting. Hence two things are necessary—predetermination of time and cost, and a means of so scheduling and controlling labor, material and equipment, through proper records, as to watch fluctuations and exceptions, with a view to cost reduction.

267 *I* Considering Normal Conditions. If costs are abnormally high, due to operating at considerably less than capacity, prices based on such costs will mean failure to secure business. If costs are abnormally low, due to night work, overtime and Sunday work, prices based on such costs will mean securing business at rates lower than you can get for your goods. In other words, from the standpoint of estimating and business-getting, costs can be used to advantage, as a rule, only when the plant is operating at or about normal capacity, and by normal we mean 80 per cent. to 90 per cent. of the possible capacity of the plant. For this reason, while providing for actual costs, standardization of costs as to burden rates should be arranged for, in order that estimating may be more uniform and the costs of real value to the Sales end of the business.

268 *J* Profits in Proportion to Complexity of Work. Methods should be so arranged as to make the most complicated work net the greatest returns in profit. For instance, two pieces of work may cost $1000. On one there may be $300 worth of labor. On the other there may be only $150 worth of labor. If 20 per cent. is added to the cost of both for profit, making the price in both cases $1200, no provision has been made for the degree of complication. As time of workmen and equipment is the real productive investment in industry, it stands to reason that a concern should get more for the job taking $300 in labor than for the one taking $150, and these differences the cost-keeping and price-making should reflect.

As all will admit, these are worthy aims, and the very purpose of Graphic Production Control, at least according to the author's vision, based on years of experience in industry, is to incorporate them as planks in the platform of the campaign, and use them as the basis of the work to be done.

Having outlined the real aims and purposes of Graphic

Production Control, the next step is to draft a set of specifications, the observance of which will conform to the requirements above outlined.

269 Specifications of Graphic Production Control.

A A means for furnishing an estimated or predetermined time and cost by operation of various orders, against which can be entered the actual time and cost, thus facilitating a study of the differences between the estimated and the actual figures.

B Standardized overhead rates by departments, which would reflect normal conditions (80 to 90 per cent. of the capacity), and which could be used to advantage in selling and estimating.

C Actual monthly overhead figures by departments, with arrangements whereby the difference between standard and actual could be closed monthly into a Burden Adjustment Account, which could be taken care of from time to time as judgment dictates.

D The cost of every order, including the proportion of overhead, and showing profit or loss.

E Monthly statements from books of accounts furnishing twelve opportunities per year to analyze results.

F Show the profit or loss of each order, of each class of business and of each department of the plant.

G The book inventory of the various materials on hand, according to raw materials, semi-finished materials, work in process and the various kinds of finished products.

H Accurate monthly record of the various expense accounts entering into the total burden, making possible a preparation of monthly burden statements for a comprehensive comparison of each of the burden accounts—a comparison that would furnish a close check on expenditures.

I The time and cost of labor, both direct and indirect, according to operation, order or expense classification, along with quantities produced, both good and bad, with comparisons of actuals against predetermined estimates or standards, thus resulting in efficient *labor control.*

J Idle time of equipment, reasons for idleness and cost of same, if desired, resulting in *equipment control.*

K Knowledge of raw and semi-finished materials on hand, of work in process, where located, quantities and the cost, resulting in *material control.*

L Careful process and final inspection, analysis of rejections as to work, causes and men responsible, resulting in *product control.*

M Relative importance of the various parts of an order, from the standpoint of purchasing, processing and assembly.

N Pieces received from the outside or from the foundry or forge shop; pieces processed according to part and operation, and the units assembled, at any given time.

O Apportioning the work to be done against equipment or departments in such a way as to show congestion or excess capacity.

P Performance of machines or operations against estimated productions, showing gains or losses.

Q Manufacturing schedules showing dates work should start and finish, with provision for showing progress.

R When necessary to revise schedules to relieve congestion, or to meet conditions caused by absence of workmen or breakdown of equipment.

S Delays between operations.

T Work released for next operations.

U Where to apply pressure to secure an even flow of production.

270 With a clear-cut outline of the specifications of our Graphic Production Control system, the acceptance of which will give us what we desire as expressed in the "aims and purposes" of the methods contemplated, the next step is to design the machinery that will meet the specifications.

271 This machinery will be made up of—

A Forms, records and devices.

B Control mechanisms (boards and charts).

C Control Department in which the work is centered.

D Personnel which operates the machinery.

272 *A* Forms, Records and Devices. The whole work of Graphic Production Control can be said to center around the control of labor, equipment, product and material, hence what records are devised must be planned with this in view. The following is an outline:

273 As to Material, the factors are procurement, following up and tracing shipments, storage, issuance, and transportation in the plant, so we will need—

a Purchase and receiving records, with which to secure materials.

b Follow-up records to expedite deliveries.

c Stores records on which to record the condition of material on hand.

d Requisitions through which material is issued and as a basis for crediting the stores for material disbursed.

e Identification and move records as the basis for knowing what material is, to facilitate movement and to schedule its progress from place to place.

f Material-returned records to act as the authority for returning to stores any material not needed or not used.

274 As to Product, the factors are knowledge of what goes into the manufacture, relative importance of sub-assemblies and parts, analysis of operations showing sequence and estimated times and equipment used, knowledge of what to build as to kind and number, progress of orders, the quality of the manufacturing and the amount of work spoiled and found defective, which makes necessary—

a Bill of material showing what enters into the product.

b Analysis of importance as to the flow of sub-assemblies and parts.

c Lists of operations of parts, and their sequence, times and equipment used.

d Schedules of operation times and equipment used.

e Sales and production orders showing what to build.

f Progress records showing what has been built and what remains to be built.

g Inspection records furnishing information as to the quality of the product.

h Rejection records covering spoiled and defective work and the causes.

275 As to Labor, we desire to know a number of things, namely—

Was the worker in?
How many hours did he work?
What is his rate per hour? Or the piece rates?
What are his earnings for the day?
What different jobs did he work on?
How much time did he work on each job?
How many good pieces did he produce on each job?
How many bad pieces on each job?
What was the standard hourly rate of production on each job?
What was the actual hourly rate of production on each job?
What was his efficiency ratio of standard to actual on each job? For the day?
What is the cost of each job?
What should the job have cost?
Does the cost and time on all jobs correspond to the time spent in the plant and the wages paid?

276 To get the above we provide—

a Time cards showing the time taken on work, the cost of same and the quantities produced.

b Allowance cards making time allowances or credits for delays, other than idle equipment, not within the worker's control.

c Rejection cards which charge the workers with spoiled work and credit them with defective work for which they are not to blame.

d Idle time cards which credit the workers for delays due to idleness of equipment.

277 As to Equipment, we want to know the idle time of machines and the reasons for it, we want to know the condition of equipment and we want to anticipate delays and breakdowns, so we arrange for—

a Idle-time records showing amount of idleness according to equipment, reasons for same and the cost of idleness, if desired.

b Equipment inventory showing what is on hand in the way of machinery and tools, and the condition of same.

c Equipment inspection records showing conditions of equipment as regards what is necessary or will be necessary in the way of repairs or attention.

278 With labor, material, product and equipment under proper control, you have all the elements necessary for *cost control,* which, through the medium of the following, will coördinate the production with costs in an efficient manner:

a Payroll records to show what has been spent for labor of all kinds, where it was spent and what it was spent for.

b Material records showing distribution of material costs according to orders and proper accounts.

c Expense accounts, burden classification or code of numbers acting as clearing houses for the different kinds of expense items.

d Journalizing records to get cost elements into the accounting books.

e Cost records showing distribution of costs by orders, expense accounts and burden classification.

279 No, the Above is not Red Tape. A review will show that these elements are standard practice in any well organized business. An argument could be worked out for each factor, but this would not only take up too much time and space, but should be unnecessary in this age of advanced methods in industry. Where modern methods have failed to secure results, it will be found that the matter of their proper coördination has not received the proper amount of attention. Tie together these necessary—in fact, indispensable—elements, and present the results graphically, and you have Graphic Production Control, which leads us to the next component part of the machinery—

280 *B* Control Mechanism. In this there are four elements:

a Material control charts.
b Order progress charts.
c Dispatch boards.
d Control boards.

281 In a complete installation all four could be used to decided advantage. In others not so complete, certain elements can be dispensed with, as, for instance, the control boards where the material control charts are comprehen-

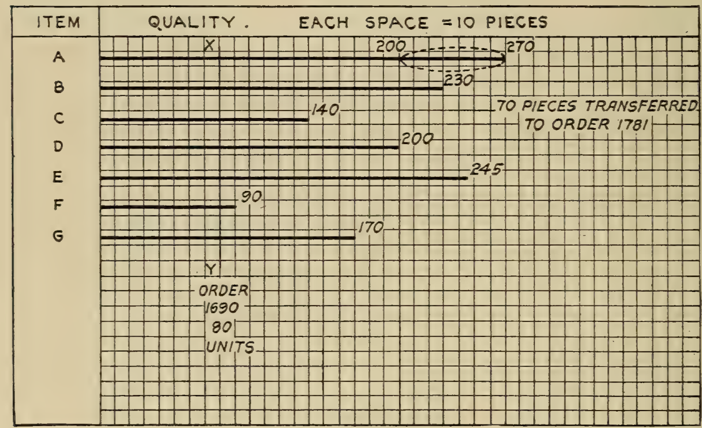


FIGURE 7. PRINCIPLE OF GRAPHIC MATERIAL CONTROL

sive enough to plan from. In some cases the control boards contain sufficient material information, and the material control charts can be dispensed with. Dispatch boards are always necessary where time of men and equipment is to be kept. Where orders are the basis of manufacturing, order progress records are necessary.

282 Instead of going into elaborate descriptions of methods covering the above controls in this chapter, the underlying principles of each will be explained in such a simple manner as to convey more clearly the ideas in mind, leaving to subsequent chapters a more detailed description of procedure.

283 *a* MATERIAL CONTROL CHARTS. As will be seen in Figure 7, the principle here is the use of straight horizontal

lines, representing quantities. Assume that items A to G represent component parts of a sub-assembly, and reference will show the amounts of each on hand. It will be further noted that no more assembly can be done beyond the quantity shown at F (90 pieces). *This is the limiting material.* The vertical line X-Y indicates the quantity assembled, which shows that 10 pieces are left, available for assembly at item F. Further, it has been found, we will say, that on order 1781 there was a shortage in item A, so 70 pieces are deducted from order 1690 because of the large balance of

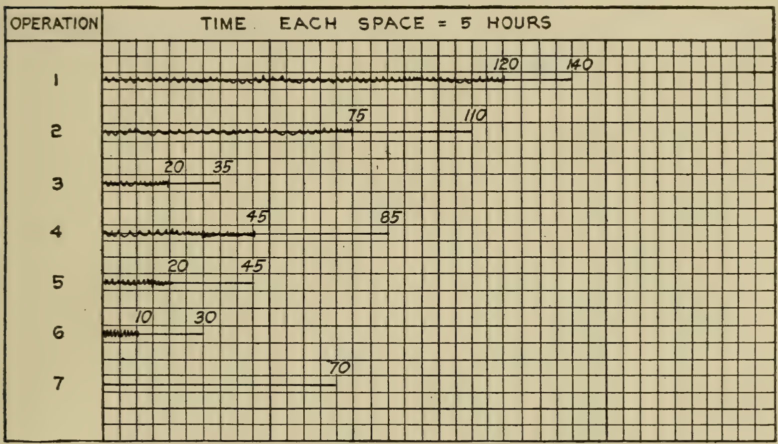


FIGURE 8. PRINCIPLE OF GRAPHIC PROGRESS CONTROL

item A, and transferred to order 1781, and the quantity (70 pieces) rubbed off the sheet as shown by dotted line—the entries having been made in pencil. To show the exact material situation, limitations and to arrange for transfers and assembling, nothing could be more simple or more graphic.

284 *b* ORDER PROGRESS CHARTS. From Figure 8 it will be seen that time to be performed (in standard hours) is expressed by a straight horizontal line, and that actual time spent on operations is expressed by a wavy line covering the straight line, the balance, not covered by the wavy line, being the work still to do. Reference to this chart will show it to be exceedingly comprehensive, decidedly graphic and simplicity itself. A glance will show—

1 Operations in sequence.
2 Hours of standard time to do.
3 Hours in actual time performed.
4 Hours still to be performed.
5 To what extent the standard time exceeds or is exceeded by the actual time.

In other words, exact condition of operations is shown at

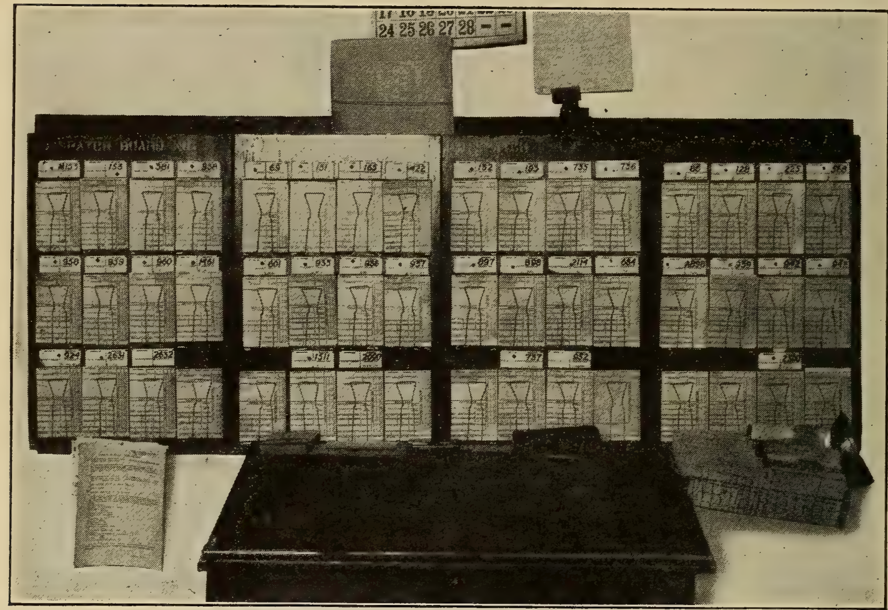


FIGURE 9. A MACHINE SHOP DISPATCH BOARD

all times, besides furnishing an excellent means for determining just where to apply pressure.

285 *c* DISPATCH BOARDS. Dispatch boards are the operating department "intelligence stations," where the current day's work is posted in the sequence in which it is to be done. They are accordingly made to accommodate one day's time in jobs ahead, and are located in close contact with working places and machines. Each group of dispatch boards is in charge of a dispatcher who registers starting and stopping times of operators on work tickets, enters units of work performed and arranges for process inspection, and calls to the attention of foremen and noti-

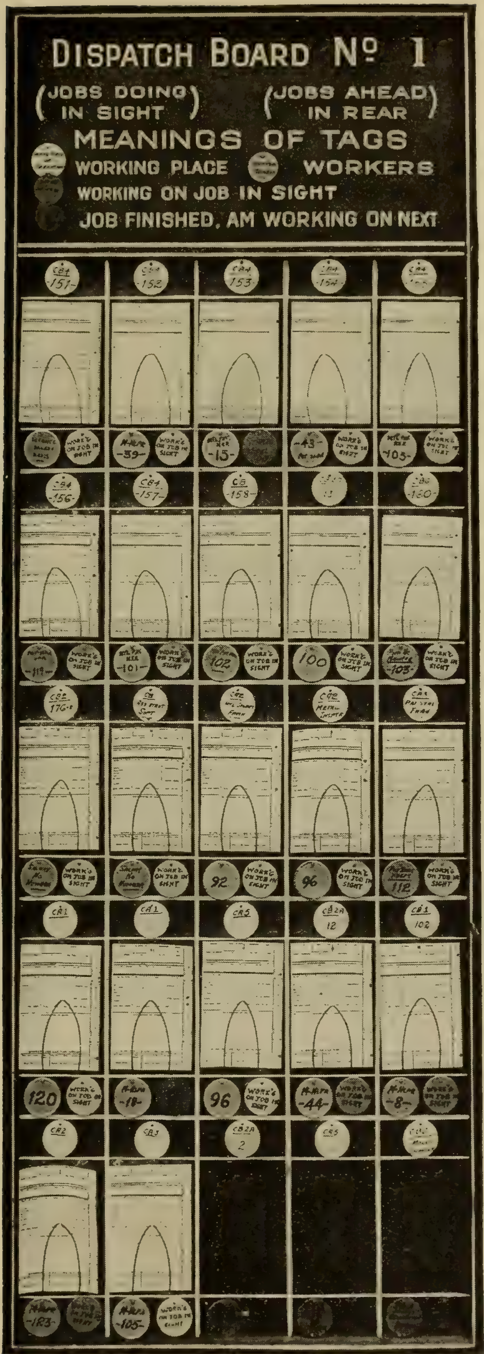


FIGURE 10. A FOUNDRY DISPATCH BOARD

fies the Control Department by telephone of any actual or anticipated conditions interfering with scheduled production. Figures 9 and 10 illustrate dispatch boards. Each working place or machine has a space on the board, the time records being held by spring clips, the cards being arranged in the order that the work is to be performed, so that the dispatch board, in addition to being a time-keeping

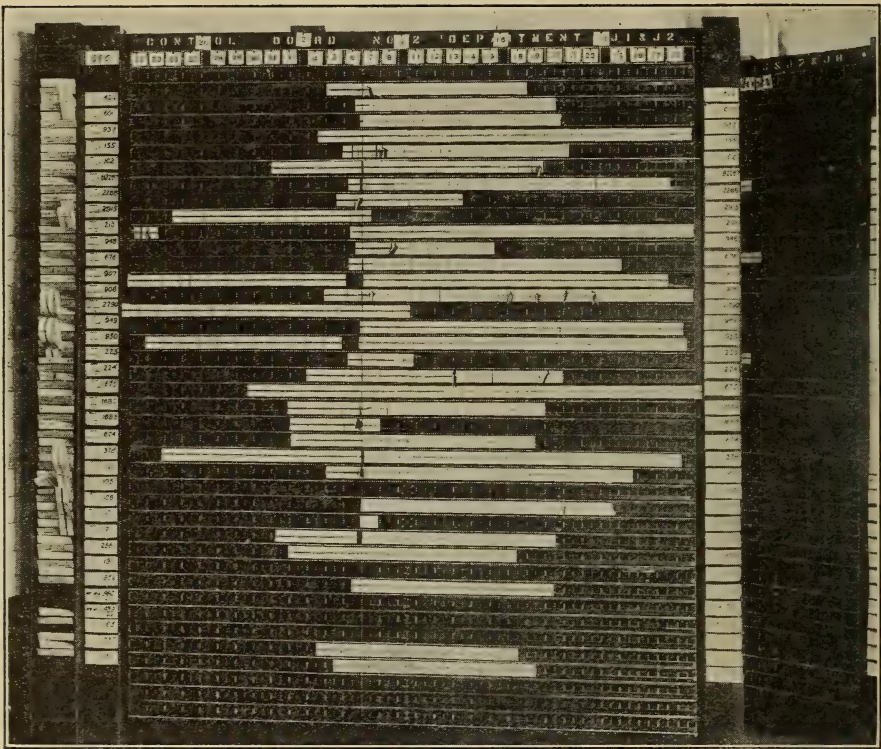


FIGURE 11. A PRODUCTION CONTROL BOARD

and production-registering mechanism, is also a "job ahead" board.

286 *d* CONTROL BOARDS. Figure 11 illustrates a type of control board now being used in a large number of installations. On account of its almost universal applicability to machine shops, foundries, structural plants, woodworking shops and process plants, like rubber factories and the like, the feeling is that in time control boards of this type will be in general use.

287 The principle of the control board is well illustrated

in Figure 12, and is of such far-reaching importance to industry as to justify more than a casual examination. The basis is—

1 Having for all important operations a standard hourly production, even though it may be expressed in the form of a crude estimate to begin with.

2 The use of a strip of paper, with graduated time scale, cut to the length of the job, in terms of the standard or estimated hours.

Note.—The number of pieces to be done is divided by the standard hourly production, which gives the length of the strip in hours, the strip being cut accordingly.

288 The strip as cut is posted on the control board, opposite the machine or working space that is to do the work, the left-hand edge being placed under the date, or hour of the date, that the work is to start, the right-hand edge showing when the work is supposed to be completed. As material is received, the equivalent standard hourly production is entered in green, as shown in Figure 12. As work is completed, the green is covered with black, corresponding to the hours of standard production turned in by the operator. In other words, the operation strip is both charged (with material as received, in green) and credited (with performance, in black) in the same terms—standard hourly productions—found by dividing the pieces received or finished by the standard hourly production.

289 The reason for this is that if the operator works at a faster rate than the standard hourly production, he is naturally ahead of his schedule, while if he works at a slower rate, he is behind his schedule, and this is the very kind of information we desire to show graphically. By crediting in the same terms as charging, we have a means of telling how much longer an operation is going to take, or how much time will be gained. All this is graphically indicated through the use of vertical date plumb lines (C-C) on Figure 12, both being moved one day's space to the right each day. All green entries (material) and all black entries (performance) to the right of the vertical red line (representing end of current day) show material and performance *ahead* of schedule. All entries of green and black to the left

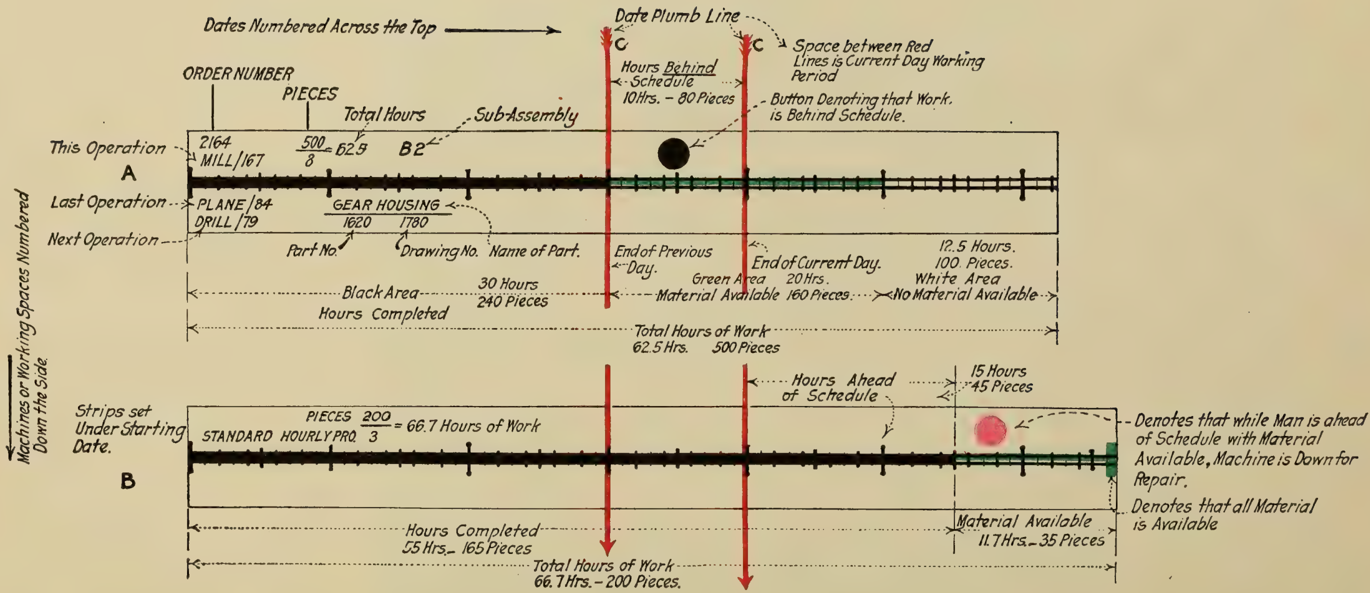


FIGURE 12. PRINCIPLE OF PRODUCTION CONTROL BOARD

indicate that material and performance are behind the schedule. The red vertical line for beginning of day is shown for convenience only, and by representing the work done up to the end of the previous day, enables the eye to determine the real progress during the current day, in the space between the red vertical lines. Reference to chart shows that operation A is behind the schedule as to performance and ahead as to material, and that operation B is ahead both as to material and performance.

290 Signals are shown to indicate conditions of work, as, for instance, at A, that operation is behind (by black button), and at B, that it is stopped because machine is down for repairs (by pink button). Key to signals is shown in Figure 13.

291 As can be seen from the control board as illustrated in Figures 11 and 12, the information that can be gathered from this form of graphic presentation is as follows:

1 Hours of work scheduled ahead of machines and working places.

2 Hours of work ahead for which material is available.

3 Starting times—at left hand of strips.

4 Finishing times—at right hand of strips.

5 Standard hourly productions.

6 What work is ahead of schedule.

7 What work is behind schedule.

8 All delays and work behind schedule, signaled so as to attract immediate attention.

9 Whether work will be completed on scheduled time or not.

10 How much longer work behind will likely take.

11 About how much gain in time there will be on jobs ahead.

12 What overtime to arrange for on work that is behind.

13 Amount of material available.

14 Amount of material still to come.

15 Unbalanced condition of material as shown by relations of green to black.

16 Amount of hours of work completed at each operation.

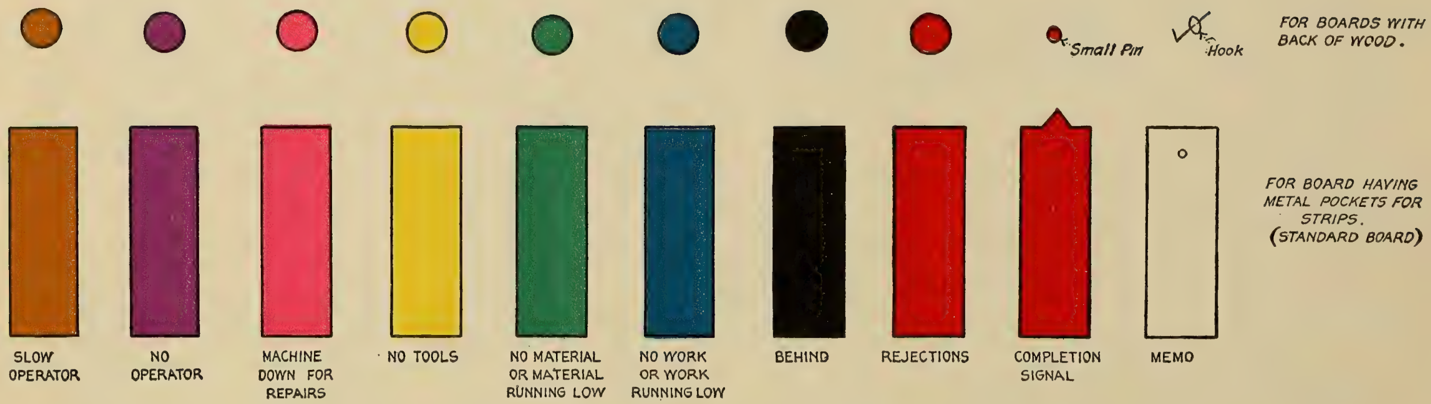


FIGURE 13. KEY TO SIGNALS COVERING IRREGULAR CONDITIONS

17 Congestion at operations as shown by strip space entirely filled with strips.

18 Idle equipment or excess capacity as shown by gaps between strips in strip spaces or by no strips in strip spaces.

19 When necessary to plan new work ahead.

20 When necessary to call on Sales Department for more work.

21 Fifty machines or working places, on any one board, with their hundreds of operations, in plain view all the time.

22 With all boards the entire department or plant according to machines or working places, with their thousands of operations in plain view at all times.

292 With elements defined and the matter of coördination through the control mechanisms considered, at least in a preliminary manner, we can take up the next cog in the machinery—

293 *C* Control Department. First of all we must arrange to centralize the work of production control—centralization was the first law of Graphic Production Control, you will remember—through the organization of a regular department of the business, which can be called The Control Department or The Production Control Department. Reference to Figure 14 will give a suggested outline for the organization of this department. As will be seen, the Production Control Department is coördinate in authority and rank with the Shop Operating Department, both being subordinate to the same general executive—the Factory or Works Manager.

294 The Production Control Department should receive from the Sales Department, through the factory management, a definite idea regarding goods sold or stock requirements, and in turn should supply any information regarding production matters required to make intelligent promises on deliveries, or determine what to make and the quantity. The Production Control Department would take the sales orders or stock requirements and prepare production orders, specifying delivery dates, which would constitute promises, work-

ing at all times for minimum costs and maximum production.

295 Both the Operating Superintendent and the Production Superintendent should work together as a unit at all times. The former is responsible for the actual running of the shop departments, being the factory executive whose duty is to get out production in quantity, of the right quality, at the lowest possible cost; while the latter looks after the office and clerical end of the factory work, being respon-

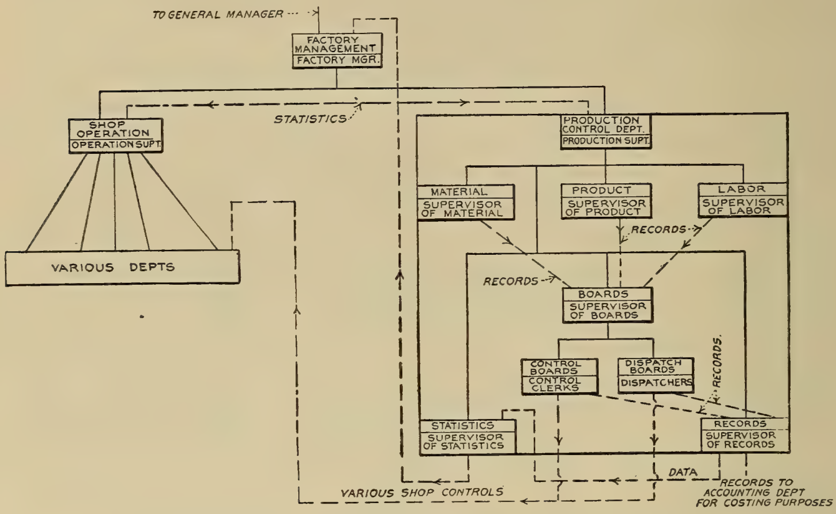


FIGURE 14. ORGANIZATION OF A PRODUCTION CONTROL DEPARTMENT

sible for planning, routing and scheduling, equipment and material control, for all information regarding the product, labor spent on work and the like. This arrangement provides a clear-cut division of performance on the one hand, and planning on the other. The one executes, the other formulates and prescribes.

296 More specifically, the Production Control Department is divided into six major functions: Materials, Product, Labor, Boards, Records and Statistics. The boards act as the clearing house for all material, product and labor records and information, as indicated by the dotted lines, while the data collected by the boards filter through to the Records Division, where the information is compiled, part

going to the Accounting Department for cost purposes, and part going to the Statistical Division, where charts and records are prepared for use by the production and operating superintendents and the factory manager.

297 In organizing the Production Control Department, it might be well to outline in a general way the responsibilities of the various sections, as follows:

298 Production Control Department, in Charge of Production Superintendent.

General direction of the various divisions of the department.

Responsibility for carrying out in the various shop departments the methods devised and accepted for efficient shop control.

Study of conditions which interfere with prompt execution of plans, or with keeping machines and gangs fully supplied with work.

Advising management as to factors which require executive attention.

Keeping work of department up to date at all times.

Holding conferences with department supervisors to assist in proper coördination.

299 Material Division, in Charge of Supervisor of Materials.

Getting jigs and drawings in readiness for work.

Supplying proper information to shop truckers and material chasers.

Responsibility for seeing that no material is moved until process and final inspection has been arranged for.

Following up shortages of material in the plant.

Keeping track of and following up material due on orders from the outside.

Replenishment of raw and semi-finished materials.

Delivery of material to proper departments and machines.

Complete knowledge as to receipts and disbursements of material.

Determination and maintenance of stock limits.

Prompt checking of requirements against stock on hand.

Responsibility for the proper handling of material requisitions.

Returning to stores material not needed or used, accompanied by material-returned cards.

Proper tagging of work to facilitate identification.

Responsibility for all stock rooms.

300 Product Division, in Charge of Supervisor of Product.

Analysis of product into sub-assemblies and parts, and the relative importance of each to the others.

Keeping after repair parts in the shop.

Following up orders—production and sales.

Analysis of parts into operations in order of sequence.

Scheduling deliveries.

Securing necessary manufacturing information, if not in the possession of the department.

Replacing spoiled and defective material.

Creation of production orders to process and assemble.

Knowledge of what to make, quantities and time allowed.

Getting estimated times on operations and compiling same.

Securing data as to best and alternate machines for given work and compiling same.

Scheduling orders received to various departments.

Keeping track of progress of all orders.

Making proper bills of material for shop departments.

Analysis of inspection and rejection reports.

301 Labor Division, in Charge of Supervisor of Labor.

Control of shop time-keeping.

Getting counts of work finished by workmen.

Checking job times against clock times.

Checking accuracy of production counts through Inspection Department.

Looking over allowance cards and idle-time reports.

Looking over rejection reports.

302 Boards Division, in Charge of Supervisor of Boards.

Routing orders to machines and gangs.

Scheduling, each day, sufficient work for the next day.

Furnishing shops with information regarding plans made.

Rearrangement of schedules to meet congestion and unforeseen contingencies, also new delivery dates.

Giving departments time sufficient to turn out work.

Seeing that everything is in readiness for jobs before they are started.

Arranging for such meetings with shop men as may be necessary properly to plan work ahead.

Reporting delays that will interfere with attainment of schedules.

Responsibility for keeping control boards posted up to date as to material received and work performed.

Responsibility for efficiency of dispatch boards.

Keeping posted as to work in process and work not started.

Keeping posted as regards when work will be completed.

Reporting on materials unattainable.

Proper handling of idle-time and allowance cards, time cards, and inspection and rejection reports.

303 Records Division, in Charge of Supervisor of Records.

The compilation of all records and data turned over to it, and sending same to the proper departments and officials.

304 Statistical Division, in Charge of Supervising of Statistics.

The proper charting of all data collected, and the presentation of same to the proper officials.

305 *D* Personnel of Control Department. The head of this department should be a man of constructive ability, with previous experience in the particular field, if possible. He should be a high-grade man in every way and possessed

of considerable executive ability, with considerable in the way of tact and diplomacy. He should be given sufficient time to familiarize himself with the details of the factory processes and the cost and production methods in use before attempting to make an active start. He should be free from routine duties, with the exception of looking after those duties specified under the head of his department.

The organization should be built up gradually; and to familiarize the personnel with the work, they should be employed at first in collecting data on machine capacities, standard hourly productions, operation names and numbers, rejection and inspection data, material movement, data on delays and idle time, cost and time data, control and dispatch-board work, and such other information as will acquaint all with the routine of the department and its divisions. As far as possible, girls should be used for purely clerical work,—and in this connection it may be said that girls make excellent and reliable shop dispatchers.

306 With this general outline of the plans for the tentative organization of the work of introducing Graphic Production Control, we can now proceed to the third step—Preliminary Steps in Introducing Methods.

Chapter XII

PRODUCT CONTROL

307 In beginning the preliminary work in connection with Graphic Production Control, it is obvious that before we can use Dispatch and Control boards, through which we can clear all production data, we must first gather and compile the information. We must, in other words, *control* the elements entering into control.

308 As we have indicated previously, the four elements are labor, material, product and equipment. In approaching the problem in a logical manner, there should be a sequence determined upon as regards the handling of these elements. If we will stop to analyze, four questions will furnish us our guide—

1 What are we going to build?
2 What are we going to build it out of?
3 With what are we going to build it?
4 With whom are we going to build it?

—the answers to which are: Product, Material, Equipment and Labor, which is the order we will follow in our presentation.

309 As you may remember, the fourth law of Graphic Production Control (requirements) outlined the necessity of knowing what should be made, sufficiently in advance to allow time to plan and schedule the production. This spells some form of ordering from the Sales Department to the Manufacturing Department, which can be taken and converted into Bills of Material and Assembly and Production Orders. Sales order forms are so well known in industry that we will not take up valuable space in reproducing them. This also applies to Bills of Material. Sales orders may

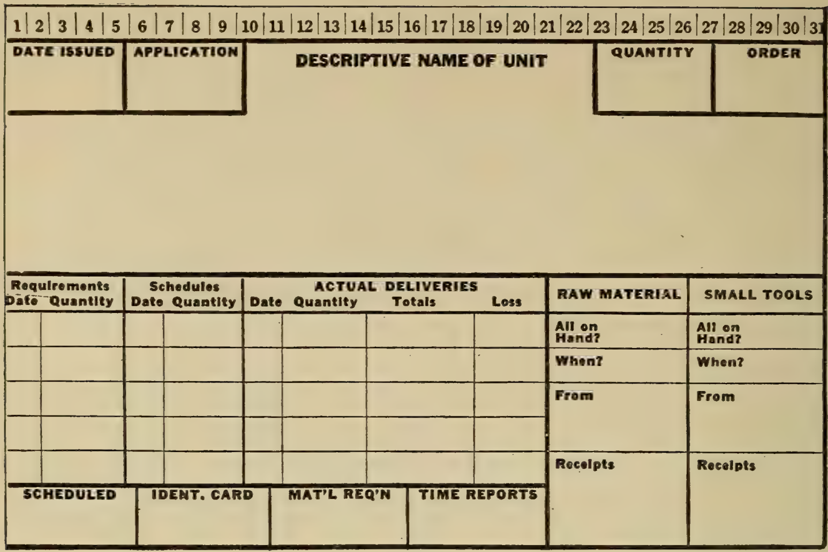


Figure 15. A Machine Shop Production Order

contain a number of different items, but production orders should be written for one item only, to each order. Across the top of the order should be a 1 to 31 scale, to be used for

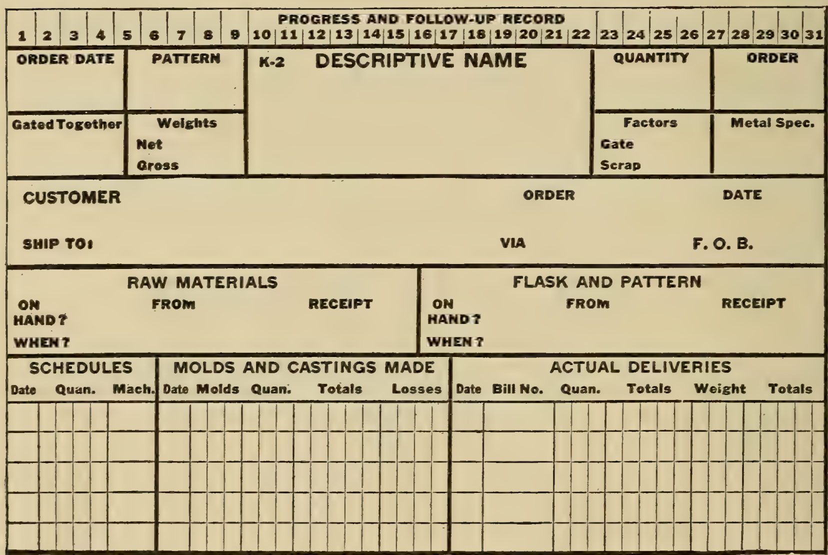


Figure 16. A Foundry Production Order

following up orders and deliveries, through the use of metal signals, as in Figure 15, covering a machine shop production order, and Figure 16 for use in connection with foundry orders. Colored metal signals corresponding to colors shown in Figure 13, could be used to advantage on production orders to indicate their condition.

310 The second law of Graphic Production Control (scope of control) should also be observed if we are to control production comprehensively. Reference to Figure 3, Chapter VI, shows a manufacturing control and schedule covering purchases, jigs, machining, sub-assembly and erection, and should be carefully reviewed in connection with this treatment of product control.

311 Now we come to the sixth law of Graphic Production Control (Importance and Availability). To live up to this law we should arrange to split up the total manufacturing into a series of assembly elements, and in so doing should give due recognition to the third law of Graphic Production Control (Draw *vs.* Push), as per the following:

Assembly Analysis

Front Axles — Order 13,805

Wanted—1,000 — Date—10/5/15

	Name of Part	Part Number	Drawing Number	Number of Pieces	Number of Hours	Buy or Make
1	Front Axle I-Beam. . .	304	30,056	1,000	733–1	M
2	Front Axle Bushing. .	131	10,772	2,000	266–4	M
3	Front Axle Bushing. .	132	10,773	2,000	166–7	M
4	Steering Knuckle, R.H.	418	10,774	1,000	350–2	M
5	Steering Knuckle, L.H.	419	10,775	1,000	350–3	M
6	Steering Knuckle Pin.	137	10,778	2,000	. . . . .	B
7	Steering Arm, R.H. . .	135	10,776	1,000	200–5	M
8	Steering Arm, L.H. . .	136	10,777	1,000	200–6	M
9	Cross Tube Yoke. . . .	139	10,780	2,000	166–8	M
10	Cross Tube.	305	10,783	1,000	. . . . .	M
11	Steering Arm Pin. . . .	141	10,781	1,000	100–9	M
12	Steering Arm Pin. . . .	142	10,782	1,000	66–10	M
13	Dust Cap	138	10,779	2,000	. . . . .	B
14	⅝ × 11 Tubing	. . .	. . . . .	1,000	. . . . .	B

	Name of Part	Part Number	Drawing Number	Number of Pieces	Number of Hours	Buy or Make
15	Pin for Cross Tube...	...	.....	2,000	.....	B
16	Castle Nut, ½″–20....	...	.....	2,000	.....	B
17	Castle Nut, 9/16″–18...	...	.....	2,000	.....	B
18	Grease Cups No. 000.	...	.....	2,000	.....	B
19	3/32 × 1 Cotter Pins....	...	.....	2,000	.....	B
20	⅛ × 1¼ Cotter Pins...	...	.....	2,000	.....	B
21	⅛ × 1 Pins...........	...	.....	2,000	.....	B

312 It will be noted that the parts have been listed in order of their importance in assembling, but that while the first part takes the longest time to machine, the fourth and fifth take the second longest time, so that from the standpoint of machining, the flow is—

Assembling Item	*Machining Item*
1	1
2	4
3	7
4	2
5	3
7	5
8	6
9	8
11	9
12	10

—which furnishes a guide for both machining and assembly. In purchasing, a different sequence may be necessary, as it can readily be seen that one of the unimportant parts from the standpoint of both machining and assembly *may take the longest time to purchase.*

313 The assembly analysis outlined the nature of the machining sequence, but as the time expressed was total time, there must be a knowledge of operation flow. In this we should give consideration to the eleventh and twelfth laws of Graphic Production Control (Starting Operations and Succeeding Operations). We should also standardize the operations wherever possible, which gives due consider-

GRAPHIC OPERATION ANALYSIS									
NAME OF PART........ PART NO........ DRAWING NO........ STUDY NO........									
BEST MFG. LOT IN PCS. 20	AVERAGE DAYS IN PROCESS 10.6	RAW MAT'L WEIGHTS PER UNIT PER LOT			FINISHED WEIGHTS PER UNIT PER LOT	MATERIAL REQUIRED KIND SIZE SPECIFICATIONS			
OP. NO.	NAME OF OPERATION	EQUIPMENT DEPT.	EQUIPMENT BEST	EQUIPMENT ALTERNATE	SPECIAL TOOLS	TIME SET UP	TIME OP.	PIECES PER HOUR	REMARKS
1	MILL						10		
2	DRILL						20		
3	TURN						5		
4	PLANE						15		
5	FACE						30		
6	SLOT						5		
							85		

FIGURE 17. A GRAPHIC OPERATION ANALYSIS

ation to the seventh law of Graphic Production Control (Operations).

314 To take care of the operation sequence, flow of

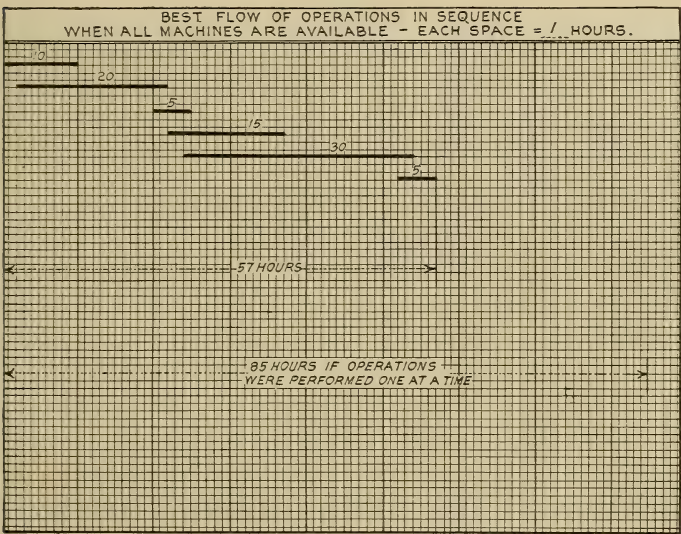


FIGURE 17A. REVERSE OF GRAPHIC OPERATION ANALYSIS RECORD SHOWN IN FIGURE 17

operations, and the standardization features, Figure 17 was designed and is called the "Graphic Operation Analysis." Provision is made for showing in addition to name

and number of part, the drawing number and the time-study number, the best lot to run, the average days to run, raw and finished material weights and the material specification. The operation sequence is shown as to the number and name of operation, the equipment (best and alternate), the tools used, the set-up and operation times, along with the standard hourly production of each operation. On the reverse side is shown the best flow of operations in sequence, with all machines available. As will be seen, 85 hours of continuous time would be required if operations were performed one at a time. By releasing long operations from the shorter ones preceding them, practically as soon as work is started at the shorter operations, as in the case of 2, 4 and 5, the cumulative time can be considerably lessened, in this case to 57 hours, or a difference of 28 hours, which shows that it pays to give consideration to the matter of starting and succeeding operations.

315 What should be considered in making up these flow charts are—

A Relative times required by successive operations; that is, long operations delivering to shorter operations, must be started some time ahead so that delivery of material to shorter operations will be in such a manner that their production rates are maintained.

B Where there is a long operation, then a short operation and then a longer operation, it is evident that it would be very unwise to wait until end of first long operation before starting short operation which follows. Much gain in time on second long operation can be made by having two or three short spurts on short operation, thus enabling sufficient material to be on hand for following long operation. The second long operation will thus overlap, in time of doing, with first long operation.

C Where successive operations are vastly out of proportion in times required to perform them, it is desirable to reduce this factor by utilizing two or more machines on longer operations, thus reducing manufacturing time to one-half, one-third and so on.

D In time allowance for movement of material from operation to operation, consideration should be given to

distance between machines, means of availability of conveyance, standard quantity which it is feasible to move in one lot, and lagging of inspection behind actual operation.

E Inspection can be regarded as an operation by itself, where it takes place after certain operations or series of operations have been performed, or it can take

Form 441 6M-9-27-4

SPECIAL WORK SCHEDULE

Part	Symbol	Group	Sch. No. S.
Mat'l	Department		Study No.
OPERATION TO BE PERFORMED			Machine
			Belt Motor
			Feed
			Speed
FOR SKETCH SEE REVERSE SIDE			Cut
Tool Steel	Tool Number		NUMBER MACHINED AT ONE TIME

STANDARD TIME

Under existing conditions and as outlined herein Standard time for the above work will be

Time for setting up	A	Time in Man / Gang Hrs.	No. of Pcs. Per	Special Fixtures—
Time for operation	B			
Time for taking out work	C	For .... Pcs.	At Time Per	
Total allowed	D	For .... Men	Is	

This is a special schedule and the management reserves the right to substitute a permanent schedule as soon as a careful study can be made of the operation.

Approved

D=Time for one piece. For more than one piece use rule Pcs x B + A + C = Std. Time.

Date Effective

Date Cancelled

See New Schedule

FIGURE 18. A SPECIAL WORK SCHEDULE

place as process inspection in more or less intimate contact with actual doing of work. In standardization of flow lines the above should be given due consideration.

F Times required for setting up machines should be given consideration but kept distinct in graphical display of flow of operations, as portrayed on our charts of standards, as well as on the control boards.

316 In working up the data for the "graphic operation analysis," a "special work schedule," Figure 18, or something of like nature, should be provided, which furnishes the basis for recording estimated times, tentatively standardizing operations, and determining standard hourly productions. As refinements are made, or time-study methods inaugurated, permanent work schedules can take the place of the special work schedules.

317 Considerable clerical work in connection with developing "special work schedules" and the "graphic operation analysis," can be saved by symbolizing operations. The code of symbols attached is offered as a suggestion.

318 STANDARD OPERATION SYMBOL CODE.

1 Space Symbol .....(-)
2 "And" symbolized by ....(/)
3 To Repeat an Operation ....Re
4 Adjust ....Adj
5 Assemble ....Assb
6 Anneal ....Ann
7 Bake ....Bke
8 Bore ....B
9 Finish Bore ....FB
10 Rough Bore ....RB
11 Burr ....Brr
12 Brush ....Brsh
13 Burr Bevel ....Bvl-Brr
14 Burr Cutting Bevel .....C-Bvl-Brr
15 Burr Edges ..Edg-Brr
16 Burr Face .....Fc-Brr
17 Burr Face No. 2 ......Fc-Brr#2
18 Burr after Mill.Ml-Brr
19 Burr after Recess ....Rc-Brr
20 Burr Screw Hole .....Scr-Hl-Brr
21 Burr after Saw ....Sw-Brr
22 Burr Thread ..Thr-Brr
23 Burr Thread No. 2 .....Thr-Brr#2
24 Center ....Ctr
25 Chamfer ....Chfr
26 Chip ....Chip
27 Chamfer No. 2 ..Chfr#2
28 Make Complete ....M-Comp
29 Core ....Cre
30 Corner ....Cnr
31 Clean ....Cln
32 Counter Bore ......CB
33 Counter Bore Back ....BK-CB
34 Counter Bore Screw Hole .....Scr-Hl-CB
35 Chuck ....CH
36 Counter Sink ......CS
37 Cup ....Cp
38 Cut Clearance ...Clr-C
39 Cut Off ....CO
40 Drill ....Dr
41 Drill Center Hole ......Ctr-Hl-Dr
42 Drill Complete ......Comp-Dr
43 Drill and Face .Dr/Fc
44 Etch ....Etch
45 Etch Trade Mark and Size ....TM/Sz-Etch
46 Spot Face ....Sp-Fc
47 Form ....Frm
48 File ....Fle
49 File Burr ......Brr-Fle
50 Flute ....Flt
51 Grind ....Gr

52 Rough Grind .....R-Gr
53 Grind on Arbor ....Arb-Gr
54 Finish Grind .....F-Gr
55 Grind Bevel and Face .....Bvl/Fc-Gr
56 Grind Shank ...Shk-Gr
57 Grind Bevel in Pairs .....Pr-Bvl-Gr
58 Grind Blank ...Blk-Gr
59 Grind Hole .....Hl-Gr
60 Grind Cutting Bevel ......C-Bvl-Gr
61 Grind End to Length ......End-Gr
62 Grind Length .Lgth-Gr
63 Grind Face by Hand .....Hd-Fc-Gr
64 Surface Grind ..Sur-Gr
65 Gr Off Flgs and Faces ..Fc/Flg-O-Gr
66 Grind Tip ......Tp-Gr
67 Harden ....Hdn
68 Pack Harden ..Pk-Hdn
69 Heat Treat ....HT
70 Hob ....Hb
71 Case Harden ..Cs-Hdn
72 Inspect ....Insp
73 Soft Inspection .S-Insp
74 Hard Inspection ....H-Insp
75 Final Inspection ....F-Insp
76 Angle Inspection ....Agl-Insp
77 Lead Inspection ....Ld-Insp
78 Size Inspection ....Sz-Insp
79 Japan ....Jp
80 Knurl ....Knrl
81 Lap ....Lp
82 Finish Lap......F-Lp
83 Rough Lap .....R-Lp
84 Match ....Mtch
85 Mill ....Ml
86 Mill Bevel .....Bvl-Ml
87 Mill Center Cut ......Ctr-Ct-Ml
88 End Mill .....End-Ml
89 Mill Under Cut ......Un-Ct-Ml
90 Mill in Two ...Two-Ml
91 Mill Slot ......Slt-Ml
92 Thread Mill ...Thr-Ml
93 Plug ....Plg
94 Pin ....Pn
95 Mottle ....Mtl
96 Polish ....Pol
97 Plane ....Plne
98 Profile ....Pf
99 Ream ....Rm
100 Recess ....Rc
101 Relieve ....Rlv
102 Sand Blast ....SB
103 Saw ....Sw
104 Season ....Ssn
105 Solder ....Sdr
106 Sanp ....Snp
107 Split ....Spl
108 Spot ....Sp
109 Spray ....Spr
110 Square ....Sq
111 Squeeze ....Sqz
112 Stamp ....Stp
113 Stamp Complete .....Comp-Stp
114 Stamp Mtchg Figure ...Mtch-Fig-Stp

115 Stamp Name and Size ....Nm/Sz-Stp
116 Stamp Patent ....Pat-Stp
117 Stamp Set Mark, Nm/Sz ..... SM/Nm/Sz-Stp
118 Stamp Trade Mark ......TM-Stp
119 Straighten ....Str
125 Mill Thread ...M-Thr
126 Rough Thread .R-Thr
127 Finish Thread .F-Thr
128 Thread Complete ....Comp-Thr
129 Tumble ....Tbl
130 Spring Temper ....Spr-Tpr
131 Tip ....Tip
132 Turn ....Trn

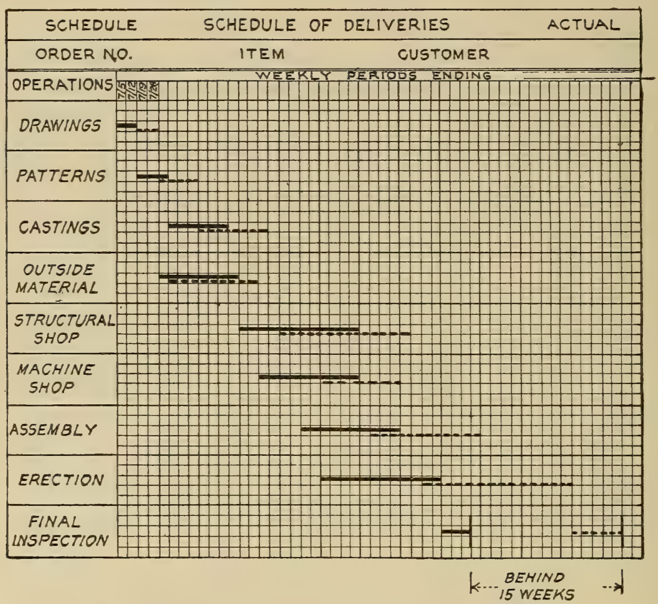


FIGURE 19. A SCHEDULE OF DELIVERIES

120 Swage ....Swg
121 Tap ....Tap
122 Test ....Tst
123 Temper ....Tpr
124 Thread ....Thr
133 Finish Turn ...F-Trn
134 Rough Turn ...R-Trn
135 Wash ....Wsh
136 Weld ....Wld
137 Spot Weld ....Sp-Wld

319 Other matters which have to do with product control are scheduling deliveries, progress of orders, rejections, and process and final inspection.

320 Figure 19 is a form of graphic delivery schedule and is self-explanatory, showing what was planned, the

actual performance, and covers work as a whole, or complete orders. Figure 20, the "anglegraph," which the author developed nearly ten years ago, and which is being

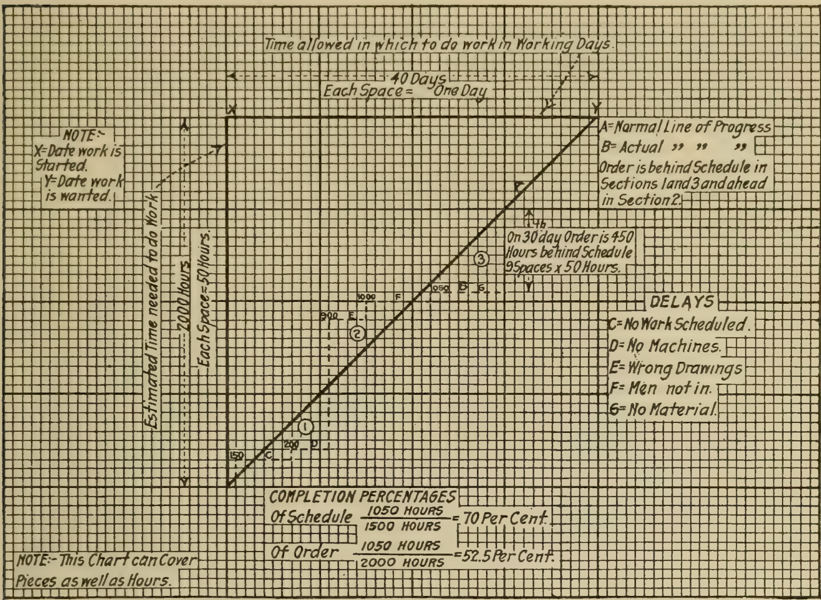


FIGURE 20. THE "ANGLEGRAPH"

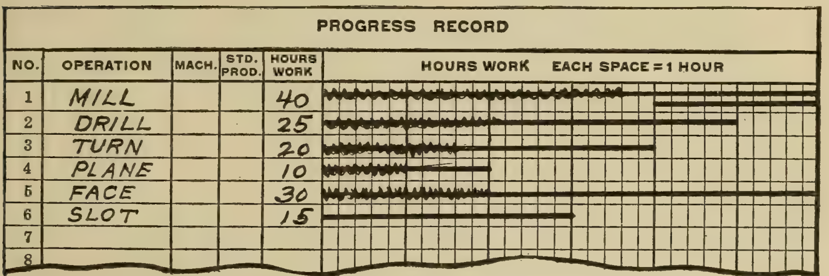


FIGURE 21. A MACHINE SHOP PROGRESS RECORD

used to a considerable extent in industry, illustrates an excellent means for controlling orders as a whole, and a careful study of same will be found well worth while.

321 For progress of detailed operations, Figure 21 for machine shop operations, and Figure 22 for structural shop operations, are offered for consideration. In Figure 21 the

principle is the use of straight lines representing estimated times and wavy lines covering actual times. In the illustration the showing is—

Operation No.	Operation Name	Est. Hours	Hours Performed	Hours to Do
1	Mill	40	18	22
2	Drill	25	10	15
3	Turn	20	8	12
4	Plane	10	5	5
5	Face	30	10	20
6	Slot	15	0	15

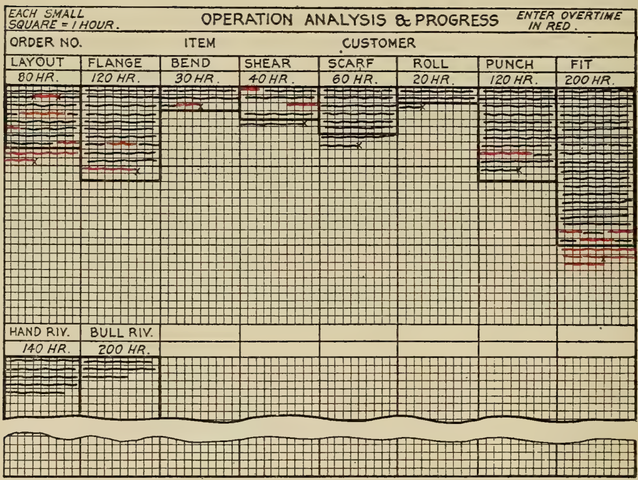


FIGURE 22. A STRUCTURAL SHOP OPERATION ANALYSIS AND PROGRESS RECORD

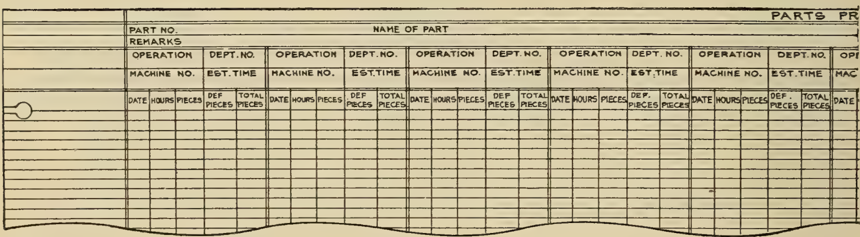


FIGURE 23. A PARTS PROGRESS RECORD

322 In Figure 22 the principle is that of the use of areas, representing the estimated time, the small squares having

straight lines drawn through them as actual time is turned in. This is an excellent record, showing progress, as actual time over or under the estimated time is apparent at a glance, as well as the overtime in red. In the illustration all operations have been finished except the hand and bull riveting.

323 Figure 21 can be used as a separate record, or the reverse of Figures 15 and 16 (production order). Figure

SHOP REJECTION CARD			
ORDER NO.	MATERIAL REJECTED	PCS.	REJECTED BY
JOB NO.			
SIZE DOORS			DATE REJECTED
REASON:	FAULT:		
WORK MADE BY MAN NO.	MACHINE NO.	DATE	
IS MAN TO BE CHARGED YES NO.		IS WORK TO BE REPLACED YES NO	

FIGURE 24. SHOP REJECTION CARD

22 can be a separate record, or can be placed at the bottom of the "anglegraph," Figure 20. If visualization must be sacrificed for extreme accuracy, the form, Figure 23, "parts progress record," can be used.

324 The factor of inspection and rejections must be given consideration in connection with product control. Figure 24 shows a "shop rejection card," which should be made out in triplicate and from which much valuable information

TS PROGRESS SHEET

LOT NO. ITEM NO. ORDER NO.

FOR MODEL NO. QUANTITY

T NO.	OPERATION			DEPT NO.		OPERATION			DEPT. NO.		OPERATION			DEPT NO.		OPERATION			DEPT. NO.		OPERATION			DEPT. NO.		OPERATION			DEPT NO	
IME	MACHINE NO			EST TIME		MACHINE NO			EST TIME		MACHINE NO.			EST TIME		MACHINE NO			EST. TIME		MACHINE NO			EST. TIME		MACHINE NO			EST TIME	
TOTAL PIECES	DATE	HOURS	PIECES	DEF PIECES	TOTAL PIECES	DATE	HOURS	PIECES	DIE. PIECES	TOTAL PIECES	DATE	HOURS	PIECES	DEF. PIECES	TOTAL PIECES	DATE	HOURS	PIECES	DEF. PIECES	TOTAL PIECES	DATE	HOURS	PIECES	DEF. PIECES	TOTAL PIECES	DATE	HOURS	PIECES	DEF. PIECES	TOTAL PIECES

FIGURE 23. PARTS PROGRESS RECORD—CONTINUED

can be compiled. One should be filed according to cause, one according to part rejected, and one according to the worker

responsible. As an example of possible compilations from these rejection cards, the record "Rejections in Foundry According to Causes" is submitted—

325 Rejections in Foundry According to Causes. Month of . . . .

Causes	Fault of Men		Material		Cores		Mis.		Total	
	No.	Wgt.	No.	Wgt.	No.	Wgt.	No.	Wgt.	No.	Wgt.
Dirty castings	3	392	32	3,043	..	....	...	....	35	3,435
Slag holes	..	....	52	3,288	..	....	...	....	53	3,288
Cold shot	2	85	6	1,400	..	....	...	....	8	1,485
Crush	37	2,625	..	....	..	....	...	....	37	2,625
Fall out	10	2,446	..	....	..	....	...	....	10	2,446
Blow	24	1,032	..	....	17	1,397	...	....	41	2,429
Hit by ladle	1	470	..	....	..	....	...	....	1	470
Scabs	11	2,522	2	563	..	....	...	....	13	3,085
Faulty closings	2	105	..	....	..	....	...	....	2	105
Shrink	..	....	5	195	..	....	...	....	5	195
Broken gates	4	2,075	..	....	..	....	...	....	4	2,075
Broken cores	1	140	..	....	1	320	...	....	2	460
Wrong cores	..	....	..	....	1	430	...	....	1	430
Hard ramming	1	40	..	....	..	....	...	....	1	40
Run out	2	645	..	....	..	....	...	....	2	645
Anchor moved	1	425	..	....	..	....	...	....	1	425
Shook out too quick	1	153	..	....	..	....	...	....	1	153
Pattern not right	..	....	..	....	..	....	1	120	1	120
Crack in casting	..	....	..	....	..	....	1	400	1	400
Pattern shifted	..	....	..	....	..	....	28	685	28	685
Faulty machine molding	..	....	..	....	..	....	9	275	9	275
Broken castings	..	....	..	....	..	....	3	560	3	560
Total	100	13,155	97	8,489	19	2,147	142	2,040	258	25,831
Per cent	50.9		32.8		8.3		8.0		100.0	

326 The matter of quality of product is becoming more and more important in industry, and plants are devoting

more and more attention to process as well as final inspection. As an example of this, the following from actual practice is submitted:

327 Standard Instructions, covering Process and Final Inspection (Brass Foundry). The function of inspection, as organized for your needs, shall consist of two divisions, namely:

1 Process Inspection, which takes place in intimate contact with actual production operations.

2 Final Inspection, which takes place when product is finished and ready for packing and shipment.

There is no better time to stop things being done wrong than in intimate contact with actual doing of operation itself. It is the logical place, inasmuch as you then anticipate and save expense of all later efforts, which may be applied on defective work. Process inspection, in modern industrial organizations, has of late years reached such a development and an intimacy with the performance of manufacturing operations that final inspection becomes quite casual. The expense of this function does not compare with the results achieved.

Process inspection shall principally take place during following operations:

1 Coremaking.

2 Molding, Pouring, and Shaking out Castings.

3 Cleaning and Finishing Operations.

328 Coremaking.

Process inspection, in operations of making cores, shall be under control of foreman of that department. This process inspection shall be of the nature of continuously checking up actual doing of operations of making cores such that good cores will result. Counts of cores *made* shall be registered as quantities placed in ovens for baking. The quantities *defective* shall be such as are lost during baking and handling preparatory to placing on storage racks. Registration of these quantities shall be made on Workers' Job and Time Reports. The difference between quantities made and defective shall be the *total made good*. This total quan-

tity made good shall have a certain specific percentage of overrun (according to type and class of core) to allow for breakage between storage racks and molding operations.

329 Molding, Pouring and Shaking Out.

In operations of making molds, pouring them, and shaking out, process inspection shall consist of continuously inspecting castings just dumped in sand-pile, in order to determine if they come up to requirements. The operation of inspection shall be periodic and proceed in definite routine so as to cover part of all castings being made by several machine, tub and floor molders. Process inspection should be sufficiently embracive, so that reasonable assurance exists that molding, pouring and shaking out molds are proceeding satisfactorily.

When discovery is made of defective castings, then process inspection for those particular molds shall become 100 per cent. The nature of defects will furnish basis for systematic initiatives to be taken relative to changing, molding, pouring, or shaking out operations so that good castings will result.

Process inspector, on discovery of work being done wrong, shall immediately notify molder, pourer or shake-out man, in accordance with nature of defect. He shall also notify set-up man or superintendent, who will at once see to it that matter is rectified and production can proceed.

Notifications as to defective work being done shall all be made in writing. Process inspectors shall use Memorandum Order for this purpose. In addition to specific location, kind and nature of defect, with pattern number of part, suggestive cause and means of remedy shall be incorporated. It will also be noted that date and time and name of party addressed are specifically required.

The process inspector retains copy of his Memorandum Order in Memorandum Order book, registers in this such additional references as he may require, and when book is completed turns same in to Production Department for analysis and summaries of defective causes.

The party addressed in Memorandum Order, after necessary action has been taken, makes notations thereon and

returns to originator or process inspector in this case. Process inspector takes note of same and turns in to Production Department for its records.

Process inspectors shall register all molds found defective, or partially defective, on Workers' Job and Time Reports located on dispatch boards and holders. When defective molds are deducted from the amounts made, we have quantity made good.

330 Cleaning and Finishing.

Process inspection of cleaning and finishing operations shall consist of periodic inspection of operations of cutting off gates, grinding, sand blasting, rumbling, chipping, straightening, punching, pickling and so on. Since definite production quantities are not at present maintained against these specific operations, this inspection shall not register quantities defective against specific operations, but shall only be supervisory of the manner of doing operations.

When, however, during cleaning and finishing operations, any quantity of castings are discovered which are defective, and such defectives have originated either before or during cleaning and finishing operations, then a Final Inspection Report is anticipated and made out. These castings, reported as defective, will be separated out and passed through final inspection, so that such anticipated Final Inspection Report may be properly authorized.

We should not forget that the function of process inspection is to hold up and remedy things being done wrong, so that the progress of production will not suffer. It is aimed to eliminate further effort on product already defective and incapable of being sold as finished product.

331 Final Inspection.

Final inspection takes place after all manufacturing operations have been completed. It is inspection of that product which has not been taken out of process during process inspection. Final inspection takes place just preliminary to shipment or passing to product stores.

Final Inspection Reports are made out during process of final inspection. It will be noted that each Final Inspection

Report has space for incorporation of inspection results on five different articles. Individual reports should not list castings belonging to more than one customer. This feature is for convenience in transferring reports of inspection to Progress and Follow-up Records.

Reports of inspection should be made complete for each batch of castings, so that operation of reporting shall be continuous and up to the minute. It is not desired that reports of castings inspected be held up for any reason.

Operation of making Inspection Reports shall embrace following preliminaries:

1 Date of Inspection.
2 Approximate Time of Inspection.
3 Customer's Name.
4 Inspector's Number.

In addition, relative to a maximum of five different castings on each report of a given customer, these matters shall be listed:

1 Pattern Numbers.
2 Quantities Inspected.
3 Quantities Good.
4 Molders' Numbers.
5 Quantities Defective.
6 Analysis of Reasons for Defects, stated by means of Defective Symbol Code.

Such Inspection Reports as are finished are first certified by chief inspector to see that requisite standards have been carried out in making them up; that is, before sending them on to Production Department, inspection work accomplished during each day shall be completely reported by quitting time. Nothing shall be left over for next day.

Final Inspection Reports are at times used as basis of scheduling preference in shipments, particularly when Shipping Department is unable to handle current day's incoming castings. Also, they are helpful in locating and inspecting together castings which should be shipped out at the same time. Further, much time is saved inspector and greater legibility is given to reports when identifying names

and pattern numbers are anticipated and written down before inspections are made. It is very evident that Production Department knows what current day's final inspections shall be, and it is for this reason that final inspection work is anticipated. The following matter, in such instances, is written out on Final Inspection Reports, the final inspector only listing counts and reasons for defectives:

1 The Given Date.
2 Customer's Name.
3 Pattern Numbers.
4 Molders' Numbers.

The accumulation of current results from process and final inspections shall be handled as follows:

1 The quantity of good molds and corresponding numbers of castings shall in each instance be registered, from Workers' Job and Time Reports, on Progress and Follow-up Record under "Molds and Castings Made."

2 The numerical losses in castings, as evidenced by defective molds reported during process inspection, shall be registered (in black) under "Molds and Castings Made" and shall be indexed by a letter (P).

3 The numerical losses in castings, as given from Final Inspection Reports, shall be registered (in red) under "Molds and Castings Made" and shall be indexed by a letter (F).

4 Accomplishments in "Cores Made" are not accumulated on Progress and Follow-up Record, but are gauged against corresponding Workers' Job and Time Reports, giving molding schedules. On each Workers' Job and Time Report, scheduled ahead, the quantities of cores actually made and necessary to take care of that production, with allowances for possible breakages, are registered. In this manner you insure that cores are on hand before molding is started. The counts of defectives in cores registered on Workers' Job and Time Reports are not transferred to other records. They are simply used as a means of criticism of the workers' daily accomplishments.

Quantities of castings are rejected and returned by customer even after such castings have passed final inspection. It is necessary that counts and weights be taken of castings returned, and that a record be kept of such returns. This is handled by registering (in red) under "Actual Deliveries" quantities and weights returned and making corresponding deductions from accumulated totals of counts and weights.

Source of information on returned castings comes from Miscellaneous Receiving Report, made out on receipt and checking by receiving clerk.

332 As will be seen, this discussion as regards the product has taken us through, from receipt of order, to analysis, scheduling, progress and inspection. In doing this, we have duly considered the following laws of Graphic Production Control:

2 Scope of Control.
3 Draw *vs.* Push.
4 Requirements.
6 Importance and Availability.
7 Operations.
11 Starting Operations.
12 Succeeding Operations.
13 Lots.

Chapter XIII

THE MECHANISM OF MATERIAL CONTROL

333 It is the writer's firm conviction that one of the most important steps in efficiently controlling production, is the proper control of material. Material must be purchased, received, stored, issued and moved before it can be used. Sometimes it is necessary to go back days, and often weeks and months, from the time material is wanted, in the process of ordering material, in order to be ready for the delivery of finished goods. In one case coming under the writer's notice, certain parts should have been ordered six months before they were ordered, that completion might be as per schedule. In another case it was found, in manufacturing a machine, that work on the smallest part, as against that on the largest part, varied as 180 to 1. Imagine, if you will, starting both of these parts at the same time!

334 In other words, given equipment on which to work, having labor in readiness, and knowing what operations to perform, nothing can be done without material on which to work, the moral of which is—*get the material and control it,* as the first step in controlling production efficiency.

335 The Control Department, through the Production Division, has received orders to manufacture and converted them into production orders; worked up a manufacturing schedule; specified flow of parts and operations according to importance and sequence; standardized or estimated operation times, and is now in a position, through the Material Division, to control intelligently the purchase and movement of material, which brings up the matter of purchases and stores.

336 It is not the intention of this chapter to go into de-

tails as to the organization of a Purchasing Department or a Stores Department. An idea of the functions of both is however, in order and is set forth as follows:

1 In purchasing, the following should be considered:

A Demand for the particular article.
B Saving by purchasing in quantity.
C Amount of money tied up in stock.
D Time required to get and use.
E Possibility of change in the design depreciating the value of the article.

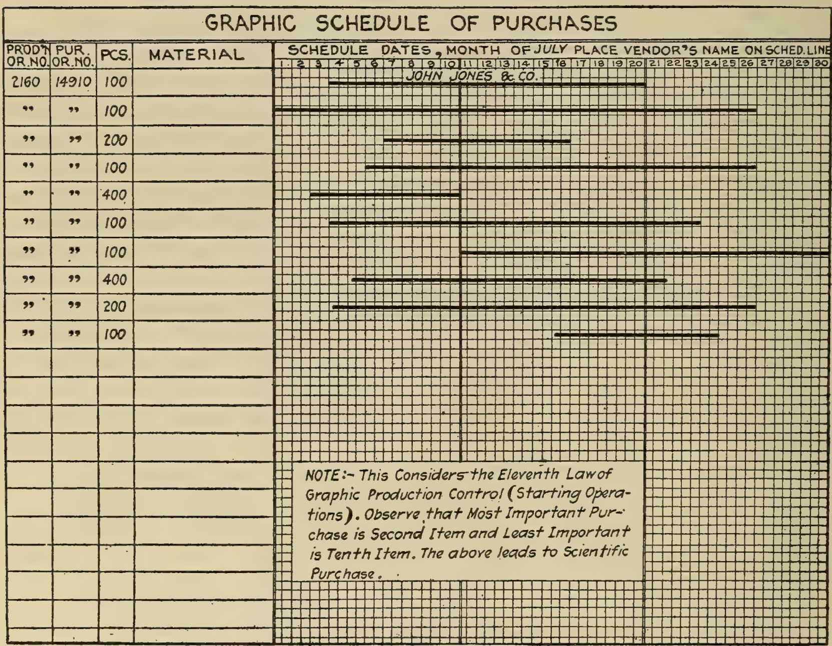


FIGURE 25. GRAPHIC SCHEDULE OF PURCHASES

2 Requisitions should be approved by some responsible head before being sent to Purchasing Department.
3 Purchasing Department should maintain an up-to-date list of quotations received and prices paid for material.
4 No order should be placed until previous price has been looked up.

5 No invoices should be sent into the plant. Receiving reports from departments (through Receiving Department) should be checked against the invoices.

6 Shippers should be made to mark plainly all consignments with order number.

7 The Purchasing Department should keep after all material ordered from advices received from the Control Department.

8 The Purchasing Department should maintain a record of spoiled and defective material received, and arrange for its return by giving proper notice to the Shipping Department, charging it back upon shipment.

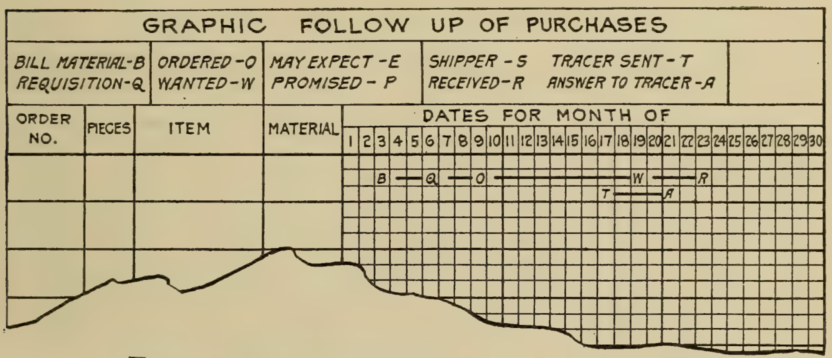


FIGURE 26. GRAPHIC FOLLOW-UP OF PURCHASES

9 No material should be issued except on requisition.

10 The Purchasing Department should keep careful records as to shortages and see to it that credit is forthcoming or the amount short shipped and received.

337 As a basis for determining delivery times wanted, the Control Department should work up the following data, going back from delivery wanted time (Draw *vs.* Push), giving consideration to the following:

A Time to process up to delivery to assembly floor.
B Time in handling after receipt.
C Time en-route.
D Time to place order.
E Time to determine vendor.
F Time to get prices.

—the sum of which would give the total elapsed time to get materials.

338 From these data the Control Department should give the Purchasing Department a schedule of purchases

PURCHASE SCHEDULE TRACER

To ☐ FOUNDRY DEPT.
☐ PURCHASING DEPT. Date__________

According to our Schedule of Purchases, your Order No.__________
Dated__________For

	Will be due Date
	Will be needed on__________(Date) or__________days sooner than anticipated.
	Was due on__________(Date) and is__________days behind schedule.

Kindly advise us regarding the above.

CONTROL DEPT.
Per__________

TO CONTROL DEPT. Date__________

You can expect shipment of above according to latest advice on__________date. Reason for delay__________

By__________

FIGURE 27. A PURCHASE TRACER

showing dates purchasing should start and dates material should arrive. See Figure 25, for a suggested form of schedule. As can be seen, the same kind of a schedule can be given to the tool room covering the making of jigs and fixtures, and to the pattern shop, covering the making of patterns. To establish a proper follow-up of purchased

items, a card or sheet record should be maintained (Figure 26), from which a purchase tracer (Figure 27) could be made out and sent to the Purchasing Department to enable the latter also to keep in touch with the progress of an order.

339 Many will say that it is a mistake to take the function of following up purchases away from the Purchasing Department. My argument is that the Purchasing Department has the same right to purchase and follow up its own purchases as the Manufacturing Department has to make and inspect its own product. If the latter is good practice, I have no quarrel with the one who would advocate letting the Purchasing Department follow up its purchases. It is not up to the Control Department to say what particular make of material to buy, nor what price should be paid, nor what concern it should be purchased from. It is an engineering function to specify the kind of material wanted. The purchasing function is to get the kind and exact quality of material specified, at the best possible price. It is the function of the Control Department, responsible for getting out production on time and at or near standard costs, to say *when,* and then follow up the purchase. On this basis we have a proper distribution of responsibility. We have a parallel in the case of actual manufacture, wherein the engineering function specifies what should be made, the manufacturing makes, and a disinterested third party, the inspection function, not a part of either and therefore not likely to cover the mistakes of both, steps in and determines the good and the bad.

340 The Purchasing Department should be in possession of advance knowledge of material conditions. It is not enough for the Stores Department simply to advise the Purchasing Department that certain materials are running low, or to send requisitions for purchasing parts to replace depleted stock. The real function of a purchasing division is to purchase in the best markets, at the best times, and to do this it must know the trend of the material situation, where too much or too little stock exists, and must know this in advance so as to anticipate what will happen, and therefore be in a position to meet salesmen coming in, and

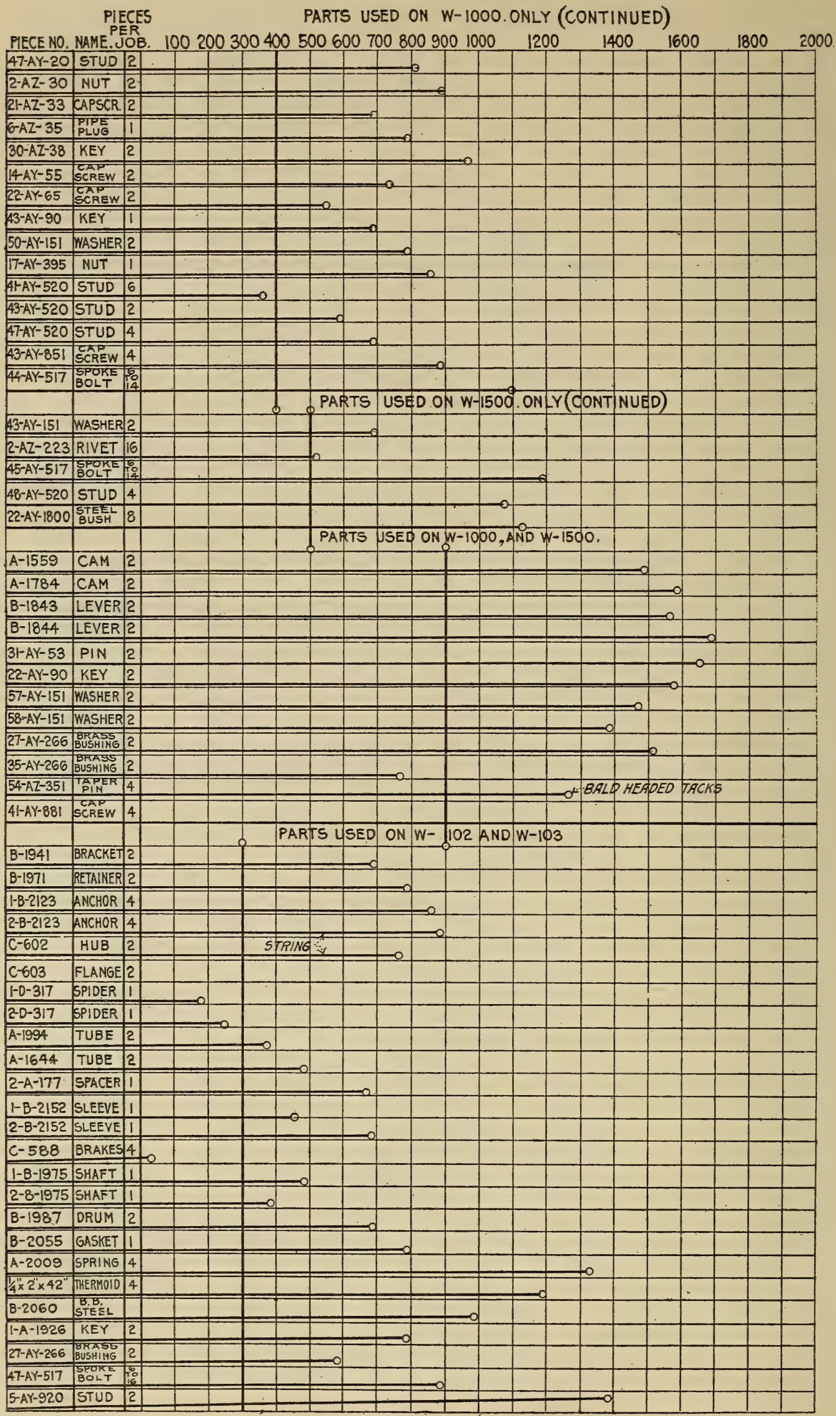


FIGURE 28. PURCHASING DEPARTMENT RECORD OF CONDITION OF MATERIAL

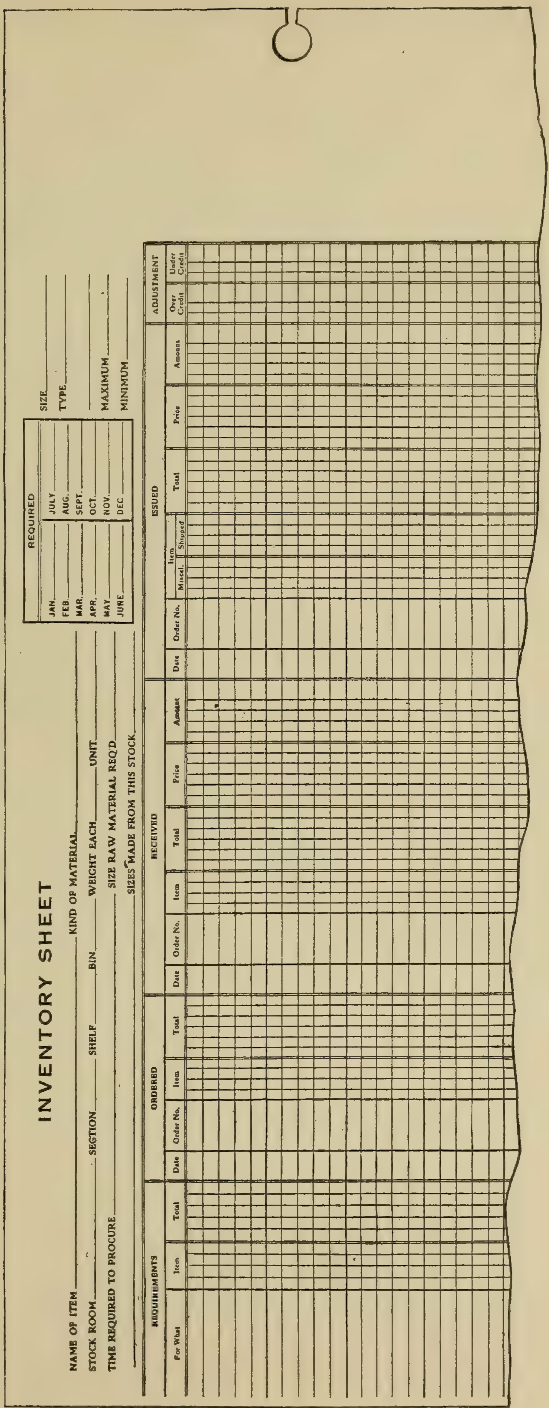


FIGURE 29. FORM OF PERPETUAL INVENTORY RECORD

take advantage of any changes in market conditions that may occur.

341 To this end it is a good plan to place in the office of the Purchasing Department, a graphic picture of the condition of important materials, this to be kept corrected by the Stores Department. The chart of Figure 28 furnishes such a picture in concise form. The vertical lines show requirements to take care of orders on hand, these being moved to the right or left as conditions change and the requirements increase or decrease. The horizontal lines indicate whether items are ahead or behind the requirements. The buttons to the right indicate that there is more material on hand

K3 PART NO. OR SIZE DESCRIPTION	STOCK CONTROL CARD	AISLE	MAX.
		BIN	MIN.

ORDERED				RECEIVED			ISSUED				RESERVED			
DATE	REQ. NO	ORDER NO	QUANTITY	DATE	ORDER NO	QUANTITY	DATE	ORDER NO	QUANTITY	BALANCE	DATE	ORDER NO	QUANTITY	✓

FIGURE 30. FORM OF PERPETUAL INVENTORY RECORD

than is necessary, while the ones to the left indicate shortages and thus show where attention must be given.

342 In the Stores Department there must be complete information regarding the condition of materials, and, to furnish an idea of the best method of keeping track of materials, the tops of two inventory records are shown in Figures 29 and 30.

343 The superior advantage of the form of inventory record shown at Figure 29, over that shown at Figure 30, is that instead of calculating the balance at every entry to the stock sheets, the figures are added in whatever column posted, at each entry, the result being at all times cumulative. At any time balances may be determined at one calculation, the value of which will be appreciated by those in charge of recording materials received and issued. In addition, perhaps the greatest aid is that reference at any time will show the up-to-date use or consumption of material, amount of material received and amount of material or-

dered, all of which is valuable from the standpoint of purchasing requirements. In cases, however, where the policy is one of calculating balances at each entry, Figure 30 is offered as a suggestion.

344 In Figure 31 is illustrated a method of keeping a

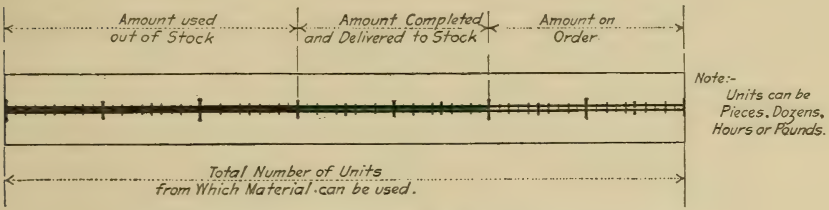


FIGURE 31. GRAPHIC MATERIAL INVENTORY

graphic inventory of material on the same strips as used in planning on the control boards; in fact, this material inventory can be used on control boards if desired. The plan described not only furnishes the inventory balance, but it also gives the amount on order, the amount delivered to stock, and the amount drawn from stock, as indicated by—

619 20M 1 19

Requisition for Material
Which is in Stock   Date..........

QUANTITY	SIZE or NUMBER	DESCRIPTION	WEIGHT	Stop Here	PRICE	AMOUNT

Charge.......... For..........
Filled from.......... Filled by..........
Ent. Stock Book by.......... Ext'd by.......... Dist. by.......... Chg'd by..........
Signed..........

FIGURE 32. REQUISITION FOR MATERIAL

A Amount on order indicated by the length of the white space on horizontal scale.

B Amount completed and delivered to stock, in green.

C Amount used out of stock, in black.

D Quantity of total units as shown by the length of strip.

345 The units can be pieces, dozens, hours, tons, pounds or any other unit desired. The plan can be used in manufacturing, in purchasing or in sales work.

346 To requisition material from stores, refer to Figure 32. The same form, of a different color and with the information called for reversed, can be used for returning excess or unused material to stores. Figure 33 is a suggested form of requisition to go with the introduction of electric tabulating machines. The same card, of different color and with the information called for reversed, can be used for materials returned.

347 The form of Figure 34 is an Identification and Move Record showing routing and is self-explanatory.

348 No argument will be made covering the advisability of using these records, as they are generally accepted as standard practice in industry and used by all well organized plants; in fact, no efficient manufacturing is possible without them.

349 Stores Department. The following brief outline of the functions of the Stores Department will furnish an excellent idea regarding its importance in controlling material:

1 To know what is needed for most efficient manufacturing.

2 To know where parts are.

3 To have material on hand in proper quantities when it is wanted.

4 To replenish it automatically when it is running low.

5 To prevent tying up too much money in large quantities.

6 To know the amount required for economic running of jobs.

7 To maintain a correct balance at all times.

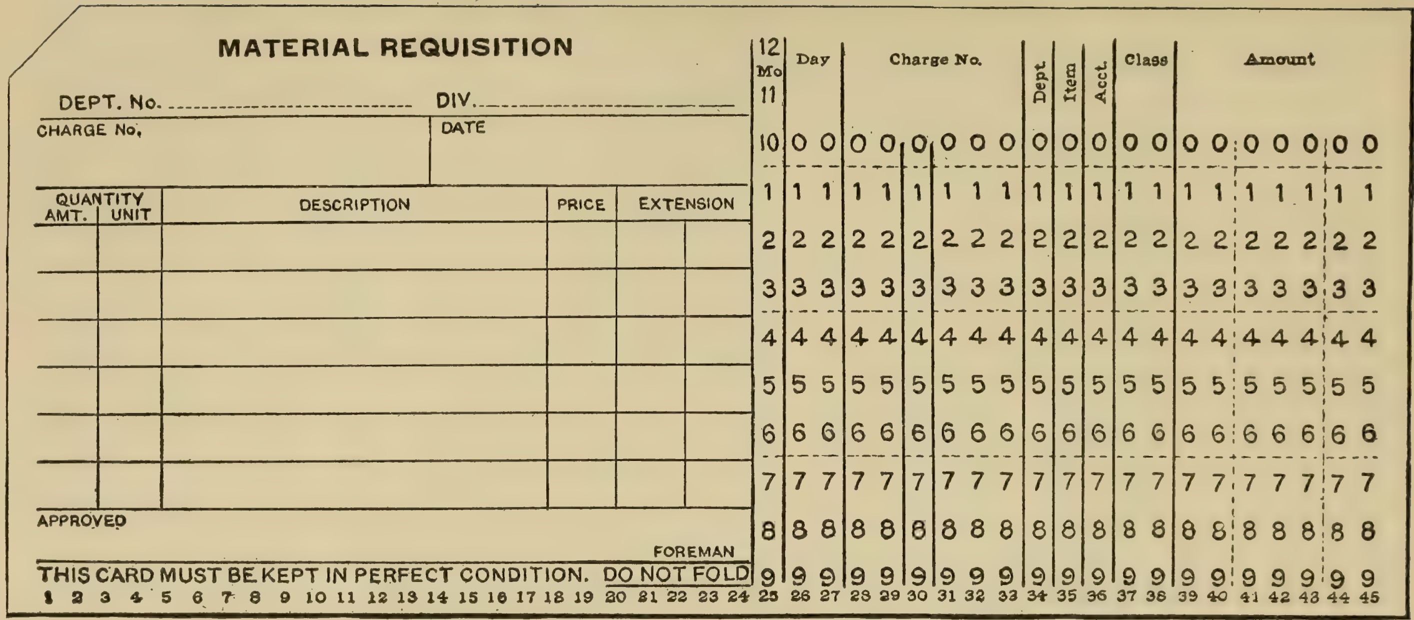


FIGURE 33. MATERIAL REQUISITION ARRANGED FOR MECHANICAL TABULATION

8 To know that material drawn from stores is charged to some order or account.

9 To keep track of material reserved for orders.

10 To issue nothing except on written requisition.

K8

IDENTIFICATION AND MOVE CARD

ORDER NO.	ORDER DATE	FINISH DATE	QUANTITY

DESCRIPTIVE NAME OF PART	PART NO.

QUANTITY	RAW MATERIAL DESCRIPTION	UNIT PRICE	VALUE

OPERATION NO.	OPERATION AND TRUCKING DIRECTIONS	NO. FINISHED GOOD	INSPECTED

(Over)

KEEP THIS CARD WITH WORK UNTIL IT IS COMPLETELY FINISHED, THEN SEND IT IMMEDIATELY TO PLANNING DEPT

FIGURE 34. MOVE ORDER AND IDENTIFICATION CARD

350 To furnish a more complete idea of purchase and stores procedure, in connection with their relation to material control, the following instructions, covering an actual installation, are offered merely as a guide. The sections covered are—

Purchase order.
Receiving materials and supplies.
Stores records.
Requisitioning materials and supplies.
Issuing materials and supplies.
Transferring material.

351 PURCHASE ORDER.

Purpose of Method: To convey information to vendors of the quantity, description, price, terms, routing and delivery of material requisitioned, and to give Stores Department a record that material requisitioned has been ordered, together with the price; to give the Receiving Department advance information on the shipment; to give the maker of the requisition information that the material required has been ordered and to give the Accounting and Cost Departments a record of material purchased, together with the price.

352 METHOD HANDLED BY—

1 Purchasing Department.
2 Stores Department.
3 Receiving Department.
4 Accounting Department.

353 PROCEDURE IN HANDLING:

a On receipt of Purchase Requisition for material, purchasing agent shall send out inquiries for prices on material covered by said requisition, except in cases where we are covered by contract on materials required.

b On material or supplies required for urgent use Memorandum Order shall be used, to be followed by regular Purchase Order on receipt of unit price from vendor.

c On receipt of information, quoting prices from vendors, original Purchase Order shall be made out and sent to vendor whose prices and delivery meet requirements, with order number, requisition number, quantity, description of goods, price and terms noted thereon. On receipt of said order, vendor shall return acknowledgment of order, with order number, date, date of shipment and signature of vendor, to us.

d One copy of the Purchase Order shall be kept on file in Purchasing Department and shall be filed in the following manner: Supplies, such as pipe fittings, etc., according to subject, and direct material entering into our own product according to blueprint number. Shipments against orders shall be applied on the back of the Purchasing Department's copy, and when the order is completed said copy shall be transferred from Current Order files to Filled Order files.

e Orders covering direct material entering into our own product shall be made out, one item on an order.

f The Purchase Order is made out in five copies. The original, containing the above information, is sent to the vendor. The second copy, with price omitted, is sent to the Receiving Department, where it is kept on a board file until the material is received, and then filed away. The third copy is sent to the Stores Department to be noted on Stores Record, and is then filed. The fourth copy is retained in the Purchasing Department. The fifth copy is sent to the Accounting Department to be used in checking price on order against price on voucher when the material is billed. This copy to be retained in Accounting Department for Cost Records.

354 Receiving of Material and Supplies.

Purpose of Method: To provide a means of recording the receipt of materials and supplies both from the shop into stores and from outside vendors, whether these latter go into stores or not.

355 Method Handled by—

1 Receiving Department.
2 Storekeepers.
3 Stores Office.

356 Procedure in Handling:

1 Materials received in stores from the shop.

a No material shall be delivered from the shop to stores without being accompanied by a Department Transfer card showing the quantity, part name and part number.

b Each storekeeper shall send a Daily Report of Materials Received in his storehouse, in triplicate, to the supervisor of stores.

c The supervisor of stores shall send one copy to the Control Department, where it shall be used in maintaining the Material Control sheets, one copy to the Purchasing Department, and retain one copy in the Stores Office to post to the Inventory cards.

2 Materials and supplies received from outside vendors.

a Whenever a Purchase Order is placed, one copy shall be sent to the supervisor of stores, who shall mark thereon where the materials are to be delivered when received and forward the Purchase Order to the receiving clerk.

b When the goods are received the receiving clerk shall check them against the Purchase Order and make out a Receiving Report, in five copies, for each consignment. Copies shall be sent to the Purchasing Department, inspector, supervisor of stores, the person ordering or the storehouse to which the goods are to be delivered, and one copy retained in the receiving room.

c Each day the receiving clerk shall make out a Record of Materials Received, in duplicate, showing each consignment received, with the road received on, shipper's name, number of packages, contents, and a note under ''Remarks'' as to the condition when received. These sheets shall be numbered serially, dated, the duplicate filed and the original forwarded to the Traffic Department to be checked against the freight bills and any claims entered.

d The receiving clerk shall forward all goods with the inspector's copy of the Receiving Report to the inspection room and thence to the proper storehouse. Exceptions to this rule are castings and other materials which, due to their nature and lack of space in the inspection room, must be inspected where they are unloaded.

e Each storekeeper shall make out a Daily Report of Materials Received, in three copies, and send them to the supervisor of stores, who shall handle them as outlined in paragraph *1 c* above.

f The storekeeper of the casting house shall, in addition, send a Report of Castings Received, in four copies, to the supervisor of stores, covering each consignment. Three of these copies shall be handled the same as the Daily Report of Materials Received and the fourth copy forwarded to the receiving clerk. This report shall show the consignor, purchase order number, car number, and the quantity, weight, drawing number or size, kind of material, name of part, and location of material.

g From his copy of the Report of Castings Received, the receiving clerk shall make out a Receiving Report in the same manner as described in paragraph *2 b* above.

h When the Invoice is sent to him for approval the supervisor of stores shall enter the voucher number on his copy of the Receiving Report and put the Receiving Report number on the Invoice as a cross-reference.

357 Stores Records.

Purpose of Method: To provide a means of maintaining a perpetual record of receipts and disbursements of all materials, as well as rejections of raw materials, due to defects. Further, to show materials available on unfilled orders, as well as prices paid.

358 Method Handled by—Stores Department.

359 Procedure in Handling:

1 A Stores Record card shall be kept in the Stores Office for each article that is carried in stores.

2 Each card shall show the blueprint number, the name, the size if kept by dimension, the weight, the low limit of balance on hand, the quantity to order, the models upon which part is used, the pieces used per job, the storehouse number, the floor, the section and the bin

number, as well as any remarks which might be necessary to make the information more complete.

3 Upon receipt of the copy of the Purchase Order, a notation shall be made in the upper left-hand corner of the card, showing date of the order, order number, quantity specified by the order, as well as the unit price.

4 The quantity ordered shall also be added to the amount as shown in the "Balance Available" column.

5 Each day the storekeeper shall send a report of materials received. These reports shall be entered upon the Stores Record cards in the following manner: The date shall be shown in the date column, the number of pieces received shall be entered in the Quantity Received column, this amount shall be added to the balance in stores, as shown by the Balance in Stores column, the balance available shall be brought down but the figures will remain the same.

6 Each day the storekeeper shall send a report of incoming materials rejected. These reports shall be entered upon the Stores Record cards in the following manner: The date shall be shown under the date column, the number of pieces rejected shall be entered in the column headed Quantity Rejected, the balance in stores will not be affected but should be brought down one line. The pieces rejected must be deducted from the amount as shown in the Balance Available column and the remainder brought down to the line below.

7 Each day the storekeeper shall furnish a report of all materials disbursed. These reports shall be entered upon the Stores Record cards in the following manner: The date shall be noted in the date column, the number of pieces delivered shall be entered in the column headed Quantity Disbursed, this amount shall be deducted from the balance in stores and the remainder brought down. The quantity disbursed shall also be deducted from the balance available and the remainder shall be brought down one line.

8 Whenever the disbursement records are entered up, the clerk shall enter the unit price on the Report of Materials Issued sheet.

9 To determine the price of materials issued when there are two or three orders available, the clerk is to proceed as follows: Subtract the last order from the balance available and the difference is the number of pieces still available at the preceding price. If this difference is less than the number of pieces recorded on the Materials Issued Report, only part are available at the preceding price. If the last order recorded in the upper left-hand corner is greater than the balance available, all materials available are at the last price shown. As disbursements exceed the quantities on order as shown in the upper left-hand corner, the exhausted orders shall be crossed out.

10 Each transaction shall use a separate line, and in every case the balance in stores and the balance available shall be brought down.

11 All Stores Record cards shall be filed first in groups by storehouse, then by rough and finished groups in each storehouse, then numerically, using the last number of the blueprint as the controlling factor. The exceptions to these are worms and wheels, bearings and thermoid, which shall be filed in separate groups and then numerically under these groups, excepting the thermoid, which shall be filed by size.

12 Every three months the balances on hand shall be compiled from Stores Record cards and a financial inventory furnished to the General Manager.

13 The difference at any time between the balance available and the balance in stores shows the balance due on unfilled orders.

14 When the quantity as shown in the Balance Available column falls to or below the amount as recorded for the low limit, a requisition shall be placed, equal to the amount as shown opposite "Order in lots of."

15 Considerable care must be taken in setting these amounts. The low limit should be set with regard to the market condition and the rate of consumption, so that when the low limit is reached there will be sufficient in stock to satisfy the requirements of the shop until a fresh supply can be received. The quantity to order should be

placed sufficiently high, so as to make it possible for the Purchasing Department to secure a good purchase price, but not so high that the amount saved on the purchase will be considerably exceeded by the interest and handling charge on the investment.

360 Requisitioning Materials and Supplies.

Purpose of Method: To provide a means of obtaining materials and supplies, and keeping a proper record of the disposition of everything that is used, so that material charges and expense items may be distributed properly.

361 Method Handled by—

1 Foremen.
2 Supervisors.
3 Office Manager.
4 Purchasing Agent.
5 General Manager.

362 Procedure in Handling:

1 Direct materials carried in stores.

a Whenever materials which go directly into our product are needed, the foreman shall make out and sign a requisition for direct material only in duplicate, and send both copies to the Control Department.

b The requisition shall show the department requisition number and a serial number, of which the Control Department shall assign a definite block to each production department. In addition, there shall also be shown the date, department number, storehouse number, quantity, name and part number of article and the order number on which it is to be used.

c The Control Department shall consult their Material Control sheets and determine whether the quantities ordered are available. Any changes necessary in the amounts shall then be made on the requisition, the original copy forwarded to the proper storehouse and the duplicate returned to the foreman.

d The Stores Department shall deliver the necessary materials to the department ordering them.

2 Indirect materials and supplies carried in stores.

a For indirect materials and supplies which are carried in stores, the foreman shall make out and sign, in single copy, a requisition for indirect materials only.

b This requisition shall show the date, department number, storehouse number, and the S-order number if the material is to be used on a construction order, as well as the quantity and description of materials desired.

c The materials shall be delivered by the storekeeper to the bearer of the requisition.

3 Indirect materials and supplies not carried in stores.

a For materials, such as lumber, crushed stone, tool steel, etc., which are not carried in stores, a requisition for indirect materials only shall be made out and signed by the foreman under whose control the material is, every time any of it is issued.

b The requisition shall show the date, department in which it is to be used, the S-order number if it is to apply on a construction order, and the quantity and description of the material.

c All such requisitions shall be forwarded daily to the supervisor of materials. Here they shall be copied to a Daily Report of Materials Issued, showing the date, order number, name of part, quantity, price and amount, and this shall be forwarded to the Cost Department.

4 Office supplies, stationery, etc.

a Office supplies, stationery, etc., shall be under the supervision of the office manager, and inventory of materials of this nature shall be handled by a person delegated by him rather than by the Stores Department.

b A requisition for indirect materials only shall be made out and signed by the foreman or head of a department for all such materials, showing the date, department number, and quantity and amount of material desired.

c The materials shall be delivered to the bearer of the requisition.

5 Materials to be purchased for stores.

a When materials and supplies carried in stores become depleted to a certain minimum, the supervisor of materials shall make out a requisition on the purchasing agent, in duplicate, showing the date, department ordering, where to deliver, materials, delivery date wanted, and quantity and description of materials.

b The supervisor of materials shall then apply a requisition number, approve it and send the original copy to the purchasing agent, and then file the duplicate by requisition number.

c The purchasing agent shall obtain the authorization of the general manager, if necessary, and then sign it himself and have the necessary Purchase Order made out. The Purchase Order numbers shall be entered on the requisition and it shall then be filed by requisition numbers until goods are received, when it shall be destroyed.

6 Materials to be purchased for departments other than stores.

a For any materials, not carried in stores, which it is necessary to purchase, a requisition on the purchasing agent shall be made out in triplicate by the supervisor of production or supervisor of maintenance, as the case may be, or by the office manager if for office equipment and supplies.

b The requisitions shall show the date, department number, where to deliver material, delivery date wanted, department requisition number, quantity and description of material and the charge symbol if it is to be used on a particular order.

c The originator shall sign all three copies, retain the triplicate as a follow-up, and forward the other two copies to the supervisor of materials.

d The supervisor of materials shall apply a requisition number, sign both copies, and forward the original copy to the purchasing agent, retaining the duplicate copy filed by requisition number.

e The purchasing agent shall then obtain the au-

thorization of the general manager, sign the requisition himself and have the necessary Purchase Order made out. The Purchase Order number shall be entered on the requisition and it shall then be filed by requisition number until the arrival of the goods, when it shall be destroyed.

363 Issuing of Materials and Supplies from Stores.

Purpose of Method: To provide a means of keeping a record of the issuing of all materials and supplies.

364 Method Handled by—

1 Storekeepers.

2 Supervisor of Stores.

365 Procedure in Handling:

1 No materials or supplies shall be issued to any one except in exchange for a proper requisition duly approved by the foreman of the department.

2 A requisition for direct materials shall be used for materials which go into the making of this company's products. A requisition for indirect materials shall be used for all other materials and supplies.

3 For materials and supplies, such as lumber, crushed stone, tool steel, etc., which are kept in sub-stores not under the direct supervision of the Stores Department, the foreman in charge shall receive a requisition for indirect materials for every issue made, and these requisitions shall be forwarded daily to the supervisor of stores.

4 From the requisitions which each storekeeper receives daily he shall make out a Daily Report of Materials Issued, as described below, and file the requisitions for a month, when they shall be destroyed.

5 Daily Report of Materials Issued.

a Each storekeeper shall make out a Daily Report of Materials Issued, in four copies, showing the date, storeroom number, the balances on hand, order numbers, part names or sizes, departments issued to and number of pieces issued, and shall forward all four copies to the supervisor of stores.

b Separate reports shall be made out for direct and indirect materials.

c The supervisor of stores shall send one copy to the Control Department, to use in maintaining the Material Control sheets, and one copy to the Purchasing Department, and shall retain the other two copies in the Stores Office.

d From one of these copies entries shall be made to the Storehouse Inventory cards. Both copies shall then be priced and one of them forwarded to the Cost Department. The other copy shall be filed in the Stores Office for a month and then destroyed.

e Requisitions for materials carried in sub-stores, but not under Stores control, which are forwarded daily to the supervisor of stores, shall be copied to a Daily Report of Materials Issued, showing the date, order number or charge on which used, quantity and name of material. This shall be made out in duplicate, priced, and one copy retained in the Stores Office and the other copy forwarded to the Cost Department.

366 Transferring Material.

Purpose of Method: To furnish a means of identifying all material sent from one department to another, and to provide a receipt and record of its delivery.

367 Method Handled by—

1 Foremen.

2 Time Clerks.

3 Planning Department.

368 Procedure in Handling:

1 A Department Transfer card shall be made out and attached to each lot of material which is moved from one department to another.

2 The Transfer card shall be made out by the foreman, or, at his discretion, by any duly authorized person in his department, but it must be signed by the foreman himself or, in a large department, by a recognized subforeman.

3 Both halves of the card shall show the department to which material is delivered, order number and item number on which it applies, piece number, amount, date, inspector's "O.K." and foreman's signature. The

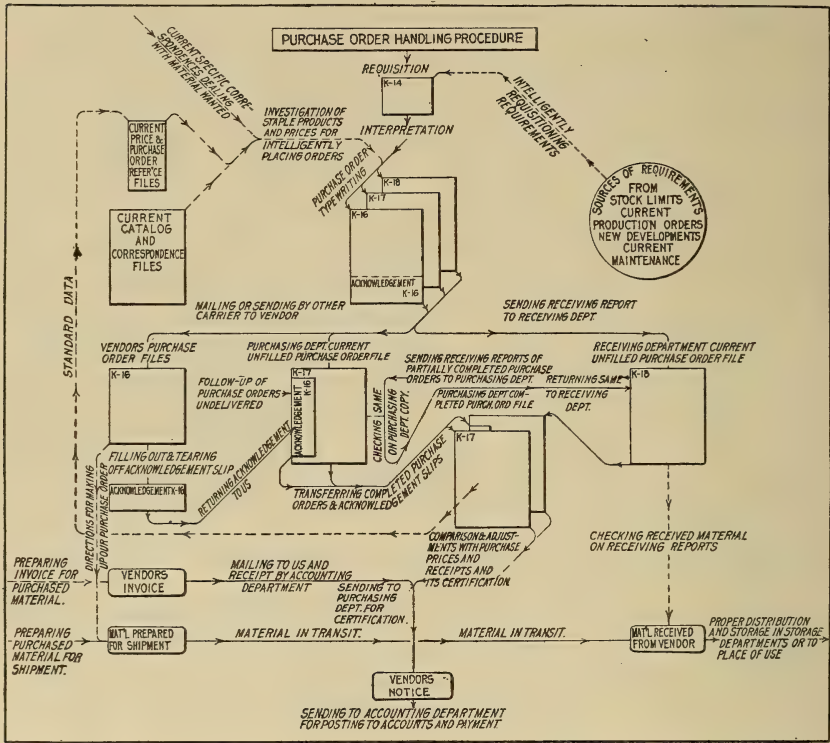


FIGURE 35. PURCHASE ORDER HANDLING PROCEDURE

spaces for customer and special number are unnecessary and should be eliminated.

4 The detachable half shall be given to the time clerk of the department sending the material, who shall make entry of the amount delivered in the proper Shop Order. He shall then send it to the Control Department, where note shall be made of the movement on the Material Control sheets. It shall be held in the Control Department for two weeks and then destroyed.

5 The stub shall be attached to the material, and, upon arrival in the proper department, shall be given

to the time clerk of that department, who shall enter the amount received on his copy of the Shop Order. The stub shall then be destroyed.

369 To portray graphically the routine of the purchasing and stores handling, Figure 35, covering Purchase Order handling, is offered as a means of getting instructions before responsible department heads and executives in concise form.

Chapter XIV

COÖRDINATING THE MATERIAL CONTROL FACTORS

370 Control boards for controlling material can be used to decided advantage in almost any plant. Condition of the material, its flow and balance, can be expressed in such units (pieces, pounds, gallons) as make reproduction on boards a simple, comprehensive and intensely graphic proposition.

371 Figure 36 illustrates a control board the principle of which is slides running in grooves. The part of the indicator strips which slide into view beyond the center of the board (vertical in one case and horizontal in the other) represents quantities of material on hand. To avoid eye-strain the indicator strips are made successively orange, blue and white. Spaces between the strips are painted a dull black. One board can cover raw materials, the other finished.

372 Figure 37 illustrates control board covering traffic conditions, and will be found an excellent means of following up important shipments. The left half of the board can cover inbound freight; the right half, outbound freight. The principle of the board is slides on which are pasted slips printed to designate a freight car. The illustration will be found to be self-explanatory. The question now arises—*Where can we see, in one place, a coördination of these different elements?*

373 Let us analyze the situation to some extent. Products which are made up of assemblies require some coördinating factor in order that individual items required will be on hand in proper amounts when the main assembly or

sub-assemblies are started. In like manner, control and follow-up of parts secured from outside require a different

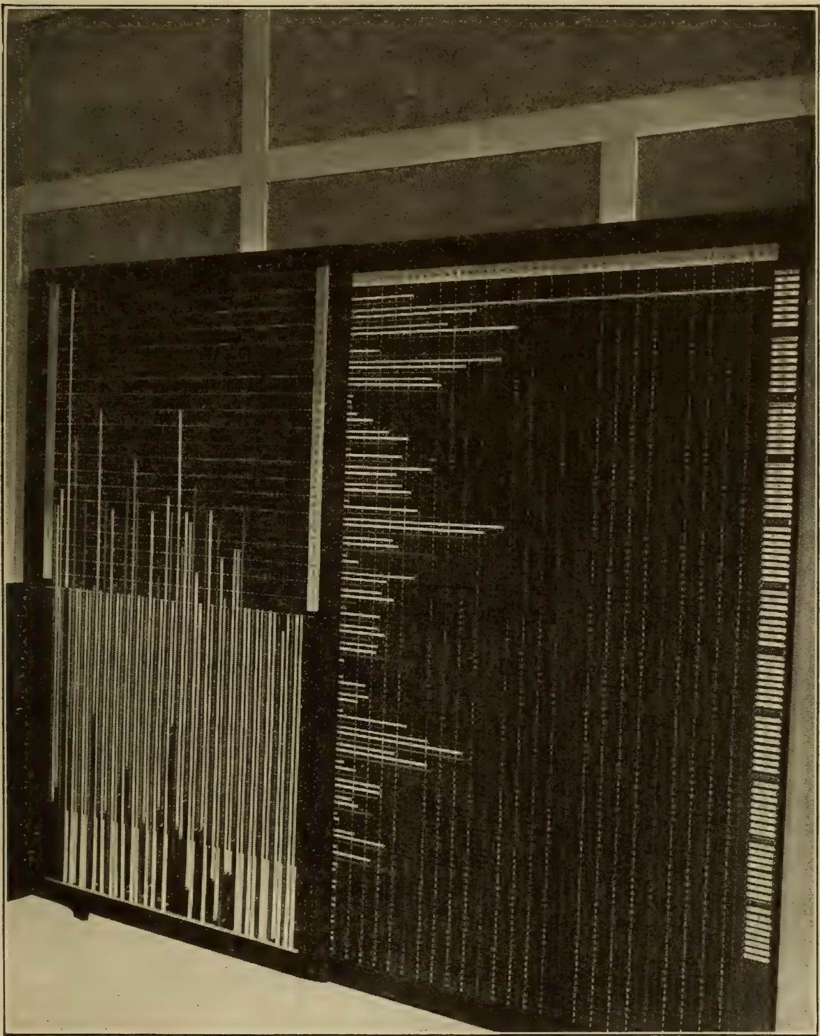
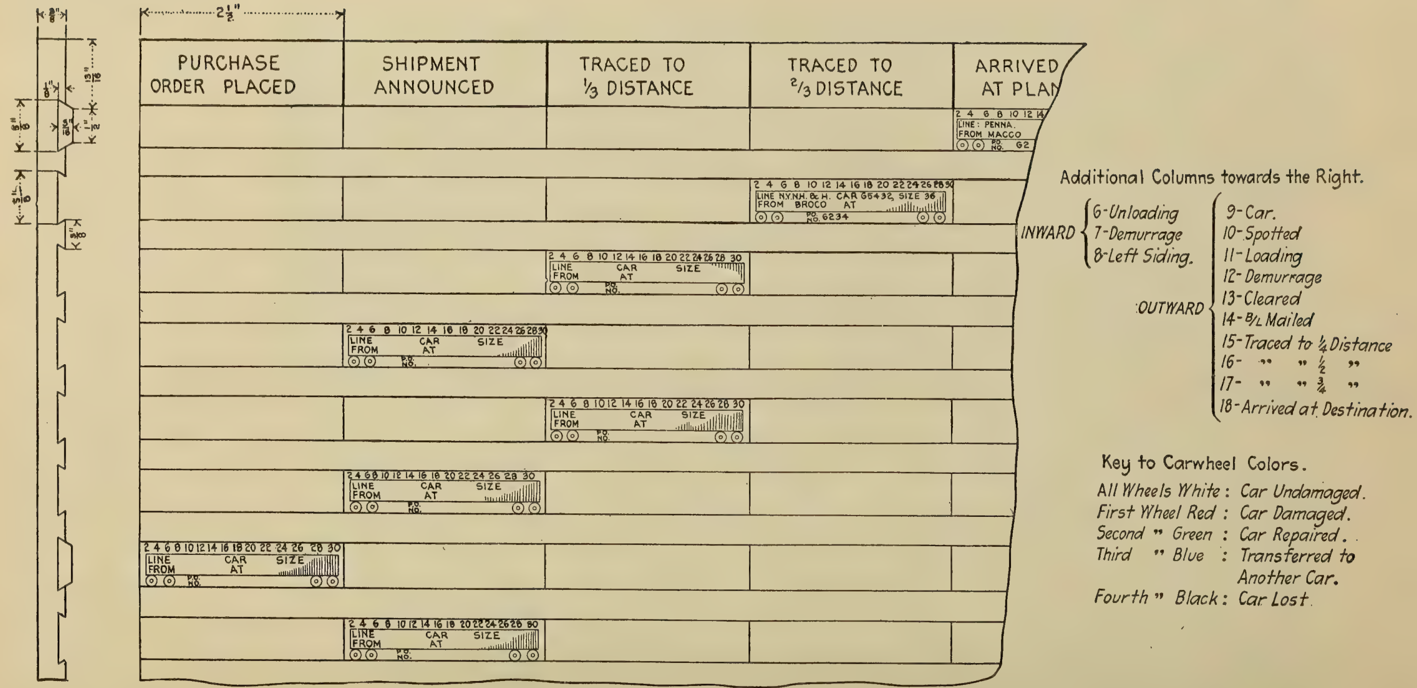


FIGURE 36. MATERIAL CONTROL BOARD

procedure than control of internal manufacturing. In building to stock requirements, control of their limits is a vital matter in that we must maintain our stocks.

374 Material controls differ from method controlling machines, benches, floors, or other production units, in that



Upper Left Corner of Traffic Control Board
Height for 39 Cars; Width for 18 Columns.

FIGURE 37. TRAFFIC CONTROL SHEET

here we control units, sub-assemblies and assemblies as to stock quantities, rather than operations of manufacture; that is, as entireties rather than elements of production. Registrations are made of units, finished or unfinished, as to individual orders of purchase or production, and not the state of completion by operation as on production control boards.

375 There are several fundamentals to be considered in controlling material. We have the completely manufactured machine; various assemblies and contingent sub-assemblies; and individual unit parts related to all of above.

376 We must first consider auxiliaries, such as design, development, patterns and tools, related to production. Second, we purchase our unit parts in the rough, scheduling, indicating progress and following up shortages in purchasing. Third, we issue requisitions for rough material and orders for shop production of unit parts; likewise scheduling, indicating progress and following up shortages.

377 Production orders for parts are finished from time to time and, finally, orders for unit parts are completed. Then comes the stage where sub-assemblies and assembly orders are scheduled and progress is followed up. Finally orders for final assembly or erection are placed, scheduled, progress is watched and we have the finished product.

378 All facts as to quantity should be displayed graphically in handling above controls. Also, we can represent time graphically, since our rates for scheduling production of finished product usually are uniform over periods of time. The time scale varies as scheduled rate of production is increased.

379 We can let one horizontal space on graphic paper represent some multiple of one unit of completely finished product, or machine. If each space represents one unit of product, and manufacturing schedule is ten per day, then ten spaces represent a day period.

380 All units, sub-assemblies and assemblies are considered in terms of completely assembled product units; that is, a space on graphic paper, representing one completely assembled unit of product, may, in turn, indicate

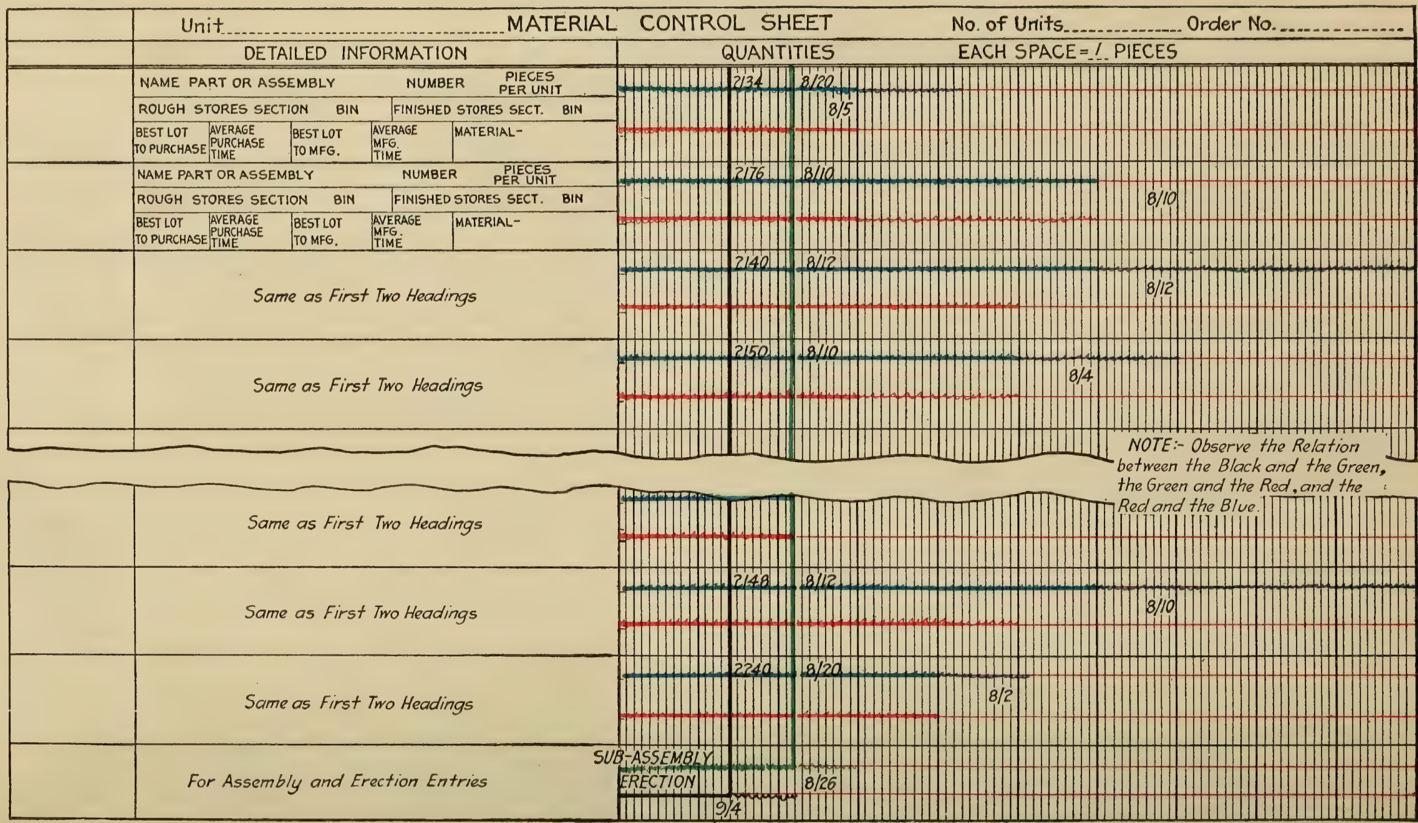


FIGURE 38. MATERIAL CONTROL SHEET—RECORD IN COLORS

one, two, three, four or more details, sub-assemblies or assemblies, according to number required in making up a unit of finished product, or one machine.

381 Material controls are usually arranged on control boards, or as charts in book form, according to circumstances or conditions in particular installations. For this discussion and to outline some new points in the use of graphic methods, we will explain a representative chart or book form of material control. We will assume that we are covering a plant manufacturing a complicated machine consisting of about 3000 unit parts.

382 The size of individual sheets or charts in Material Control book illustrated in Figure 38 is 17×22 inches. Each sheet gives available space for controlling twenty different items of stock. Horizontal coördinates are divided by vertical lines such that stock for twenty different parts for one hundred complete machines could be kept on one page, or any multiple of one hundred machines, providing we considered each horizontal space as representing more than one unit. The hundred vertical coördinates are divided in groups of ten for visualization.

383 Each one of the twenty spaces for items is titled as follows:

A The Part or Assembly Name.
B The Part or Assembly Number or Symbol.
C The Rough Stores Section and Bin Location.
D The Finished Stores Section and Bin Location.
E The Best Purchase Lot in Pieces.
F The Estimated Average Purchase Time in Days.
G The Best Manufacturing Lot in Pieces.
H The Estimated Average Manufacturing Time in Days.
I The Number of Parts per Assembled Machine.
J The Material of the Parts.

384 At top of each sheet a graphic time scale is used to coördinate the time and the production elements, as illustrated in Figure 40, this chapter.

385 Each of the twenty horizontal spaces arranged for items of stock has two light red horizontal lines, the upper

for keeping stock on material previous to machine operations, and the lower for keeping stock on finished parts during and after operations of manufacture. These horizontal lines, as mentioned before, are divided into one hundred parts by vertical graphic lines which indicate quantities of machine units, sub-assemblies and assemblies.

386 On upper side of upper light red horizontal line, conditions as to raw material purchase orders are registered, and on lower side, matters relating to raw material receipts. On upper side of lower horizontal line conditions of production orders are registered, and on lower side production receipts or clearance from inspection.

387 You will remember that we stated that there were approximately 3000 unit parts in a given machine, or product. Due to duplication of parts, there are only about one thousand different kinds of parts, and approximately sixty pages are sufficient to cover the product manufactured.

388 A logically arranged Bill of Material is the basis of writing up consecutive assemblies, sub-assemblies and unit parts in Material Control Records. You must be exact and have definite knowledge of what you are going to make and the various relationships of all parts going into the completed machine.

389 Assemblies, sub-assemblies and unit parts are listed in the Bill of Material in the order in which they are required in the erection of a complete machine, as well as assembling procedure of major and sub-assemblies. Divisions closely related will evidently be together and governed in position by their relative importance to each other in manufacturing practice. The standardized nomenclature, names or abbreviations should bear the consistency and uniformity of a well arranged Bill of Material. Pages, groups and items, as given in the Bill of Material, are used as the basis of nomenclature in Material Control sheets.

390 With above preliminary outlining of the several elements of Material Control, we can proceed with detailed explanations of the method of operation in this instance.

391 We must know, first of all, the schedule of delivery of the completely manufactured product. Whether this is one machine per day, two per day, ten per week, or a vary-

ing schedule, such as four per week for two weeks, five per week for two weeks following this, six per week for two weeks following this, and so on, we must have some definite schedule as our fundamental basis. This schedule may be varied at will, but there is a time element connected with it, and variations in the direction of increased production must be foreseen, and sufficient time must be given to bring about the greater volume.

392 This time element is, again, a variable, depending somewhat on conditions in the markets of raw material, the reserve machine capacity, difficulties in securing necessary increase in number of workmen, and so on. Delay in bringing up only one of the contingent elements reduces all to the slowest element. Thus it is very evident that, in a really scientific manipulation, we must first of all have the desired schedule of manufacture accurately mapped out for some time ahead.

393 With our schedule of manufacture laid out for some advance period, we commence to work back. With all material, units and assemblies supplied at proper times to final erection floor, we must balance our erection capacity with schedule of requirements. We have the time to start erection of each machine to consider. We must deliver at a predetermined time. We must keep the number of machines in erection process down to the lowest possible point.

394 With a rate of manufacture in erection department giving a delivery of approximately one machine per day, we have machines in erection, testing, and painting process approximately ten days, we will say. If we are subsequently able to deliver two machines per day with same number of machines in process, the time limit is cut in two; the capacity has been doubled for the same investment of material in process at this point. But, laying aside, for the present, the various considerations which may arise with handling of this erection procedure, there is a time element of ten days to consider in getting product through this final division of manufacture.

395 We must similarly treat assemblies and sub-assemblies and units, which progress along with their several time elements before they are ready for main erection line. Those

which take longest must be started first. Certain parts are in assembling, testing and painting process for at least ten days, even with all material ready at proper time for this work. Going one step further, the several machine operations on an economical manufacturing lot of other parts may take fifteen days to process through shops. We have, in addition, the fact, that it may take usually thirty days to get rough castings for this lot from time of placing purchase order. On above basis, we have a total time of sixty-five days from placing of purchase order to delivery of one of these unit parts in first completed machine. If economical manufacturing lot was twenty-five pieces, last piece will not be used up in completed product until ninety days have elapsed from placing of purchase order.

396 All of these several points of consideration must be taken care of in some way, in connection with every business of this nature. We must go through this reasoning process with every unit part, and with resulting sub-assemblies and assemblies and with completed machine. On how well we are able to do it is dependent the amount of capital which may be found necessary to tie up in product in manufacturing process. We must manipulate matters so that everything is on hand at proper time and in correct amount.

397 In manipulation of chart, we first register (over the top light red line mentioned before) amounts purchased by a light blue wavy line, the length denoting the number of machine units covered by given purchases. Purchase order number and date, with delivery required, are indicated above this line. As material is received in the rough, a blue straight line is drawn over wavy line to extent of receipt, the receiving date being indicated under this line.

398 We finally have material on hand ready for manufacturing processes. A red wavy line is drawn under blue rough material line on the lower light red line previously mentioned, as parts are ordered in process. Its extent also indicates number of machine units covered by given shop production order, or quantity of rough units on hand which are to be reserved and later used. Shop order number, date and delivery date are indicated above this line. As clearances come in on order, a heavy red straight line, with dates

of receipts indicated beneath, is drawn over red wavy line. We now have finished units on hand ready for assembling processes.

399 We now place production orders for assemblies. We draw a green wavy line to extent of number of machine units embraced in order and, at end of this line, at right angles, vertically, we draw a light green wavy line across all units contingent to assembly. This means that all these units are reserved and are to be used in making up this work. As is the case with production orders for units, the assembly order is cleared by drawing over light green wavy lines a heavy green straight line and writing date of clearance underneath. We may carry this process still further.

400 The final machine, in its erection procedure, consists of assembling certain units and assemblies. When machine erection order is placed, we draw a light black wavy line horizontally where given model of machine is listed; that is, at beginning of assemblage of sheets, making up complete Material Control charts for given machine. The light black wavy line also is to be extended vertically and across all units and assemblies which are used in machine erection. Remaining procedure is as has been explained in case of assemblies.

401 Now, when this material control record is in full operation, it is interesting to note various resulting relationships.

A We have amount of rough material on purchase order, but undelivered, indicated by light blue wavy lines. Extent of these lines as compared with schedule of delivery of completed product as arranged at top of individual pages of chart, is clearly indicative of how far you have gone in making arrangements for material for manufacture of product.

B Extent of heavy blue straight line along light blue wavy line tells us how much of rough material on purchase order has been received.

C Extent of heavy blue straight line beyond red wavy and straight lines indicates how much rough material is available and has not yet been ordered into manufacturing process.

D Extent of light red wavy lines indicates how much material is in manufacturing process or has been reserved for placing into process.

E Extent of heavy red straight lines beyond green wavy and straight vertical assembly lines indicates how many finished units are on hand and available in Finished Stores Department. If vertical assembly line is wavy, this indicates what material has not yet been delivered for Finished Stores Department and, of course, work has not yet commenced on assembly order. However, wavy line indicates that material is held in reserve in Finished Stores Department for this assembly order.

F Extent of finished assembly units is indicated by heavy green horizontal straight line and heavy green vertical straight line, crossing units making up assembly. The extent of these lines beyond vertical black machine assembly lines shows number of assemblies on hand in Finished Stores Department.

402 It may be questioned at this point as to how scrapped, rejected and defective units are handled on Material Control chart. Also, there may be some difficulty in seeing what is necessary manipulation in order to take care of those parts which may be sent out as repairs. As chart has been explained, it is evident that our lines of daily manufacturing progress all go forward in machine units; that there is no provision made for one point getting ahead of another. We cannot take out a part for repairs without replacing it, for our scheme of scheduling and indicating attainments, graphically, carries no such provision.

403 We must consider scrapped, rejected, and repair units, sub-assemblies and assemblies as extras. They are places which must be repeated; therefore, the following very convenient and instructive method of procedure is used:

404 When a part supplied by an outside vendor is found faulty it is rejected. "Rejected" is used in the sense that vendor must make replacement. We use blue pencil to register this same fact on Material Control chart.

405 When rejection is made on receipt of purchase order, we draw, commencing at end of given purchase order line

(light wavy blue), from right toward left and in space above given purchase line, a wavy blue line to extent of rejection in machine units. We also write the date above this wavy blue line indicating rejection. When, however, rejection is made during manufacturing operations,—that is, during consummation of shop production order,—we draw blue wavy line, as before, above light red wavy line, commencing at end and back from right toward left. Since relationship between rough stock line and shop production order line should not change, providing rejections on shop order are not replaced from rough stores, we repeat given rejection blue line on under side of blue rough stock line at end of given purchase order line, as before.

406 With units which are scrapped we carry on our manipulation in same manner as with rejections. We use "scrapped" in the sense that it is loss for the company, and our only salvage is the amount we may get out of the raw material. We make our indications on chart with a red pencil.

407 With units which are defective we carry on our manipulation much as with rejections, but do not extend indication to rough material line. The reason for this is that we use "defective" in the sense that it can be made right by additional work. We make our indications with a yellow pencil.

408 Now, finally, with parts applied to repair orders, we use the green pencil. Manipulation is similar to procedure with rejected parts, except that we draw green repair work line on under side of shop production order line at its end. The rough material line is handled in the same manner as with rejections. The order number and dating may be registered over lower green line for purposes of reference and of identifying where repair order was filled.

409 It is now evident that what we have done with rejections, scrapped and repair units is only in the sense of a subtraction. We have subtracted from ends of lines. To make these parts full again, it is only necessary to remember that purchase orders and shop production orders must be repeated through these gaps. There is an overlapping at every point from which a rejected, scrapped, or repair part

has been taken. We accordingly have considered rejected, scrapped and repair parts as extras, which virtually they are.

410 It is interesting to note various information which is conveyed by above method of caring for rejected, scrapped, defective and repair parts. We might list them as follows:

A Rejected parts may be easily located as to vendor who supplied them. If orders of rough or finished parts are used in the order in which they are received (which is customary), there can be no mistakes as to identity of party who supplied them.

B Scrapped and defective parts are registered against shop order where they occurred, so record is continuous and can always be located. We can also easily identify repair unit supplies, should future occasion arise.

C By recapitulations of rejected, scrapped, defective and repair parts, we are able to determine their percentages and frequencies and can in this manner arrive at many conclusions as to methods of betterment of product, provisions for quantities of stores on hand for repairs, and so on.

411 It is very evident that a schedule Progress and Stores chart furnishes a record of just what has been applied originally on each machine manufactured. Sales order numbers furnish a means of identification after machines have been in use by customers for a considerable period of time.

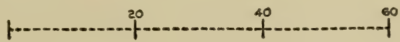
412 We have records of all essentials and a very efficient and simple method, indeed, of keeping them. With other means than by graphics, we would run into undue complication. Here we handle all main essentials for one hundred machines, each with somewhat over a thousand different parts. We handle this matter on approximately sixty 17×22 sheets. We handle it from placing out of individual purchase orders for parts, through complicated manufacturing procedure, to shipment of product to customer, and, indeed, if necessary, can go back over our sheets and trace back any part of procedure, should occasion arise, after machine has been in use by the customer for any period of time.

413 Another excellent principle in using material con-

trol charts is that of *areas* instead of light wavy and heavy straight colored lines. As will be seen in the following, the elements we desire to keep in mind are—

A Parts purchased or ordered.
B Parts on hand or received.
C Parts ordered on the producing departments.
D Parts furnished in the producing departments.
E Parts ordered assembled.
F Parts assembled.

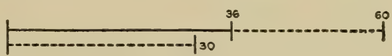
414 Assume that we have ordered 60 pieces of a part, and by drawing a dotted line we have:



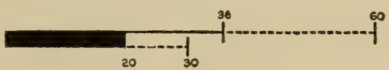
a Upon receipt of material we cover the dotted line with a full line for the amount corresponding to the amount received, and can show it as:

b This tells us that 60 pieces were purchased. 36 received, and 24 still to come.

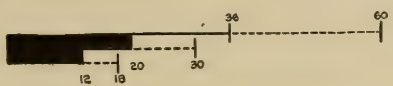
We enter an order on the factory departments for 30 of the 36 received, and can show this fact by a dotted line under the full line, as follows:



c The departments complete 20 pieces of the 30, and by covering the second dotted line by a full line we have:



d Let us assume, further, that of the parts completed, 18 are ordered assembled and 12 are assembled in the finished product, and our graph is now as follows:



SUB ☐ FINAL ☐ ASSEMBLY.

MATERIAL CONTROL SHEET.

NO. WANTED. DATE ORDERED. DATE WANTED. ORDER NO.

ITEM NO.	PIECES EACH.	PARTS FOR ASSEMBLY SEQUENCE.	PART NO.	DRAWING NO.	MACHINING		B. OR M.	PURCHASING.	
					HOURS	SEQUENCE		DAYS TO GET	SEQUENCE
1					200	6	B	4	
2					50		M	5	
3					310	3	M	20	5
4					65	12	B	8	
5					15		M	30	4
6					110	9	M	5	
7					260	5	M	5	
8					400	2	B	10	
9					106	10	M	30	3
10					24		M	15	
11					50		M	5	
12					31		M	60	2
13					160	7	B	20	5
14					280	4	B	90	1
15					500	1	M	10	
16					30		M	5	
17					19		M	20	5
18					120	8	M	10	
19					80	11	M	5	
20					60		M	5	

B=BUY. S=STOCK **GRAPHIC FLOW.**
M=MAKE. *EACH SPACE EQUALS 1☑ 2☐ 5☐ 10☐ UNITS.*

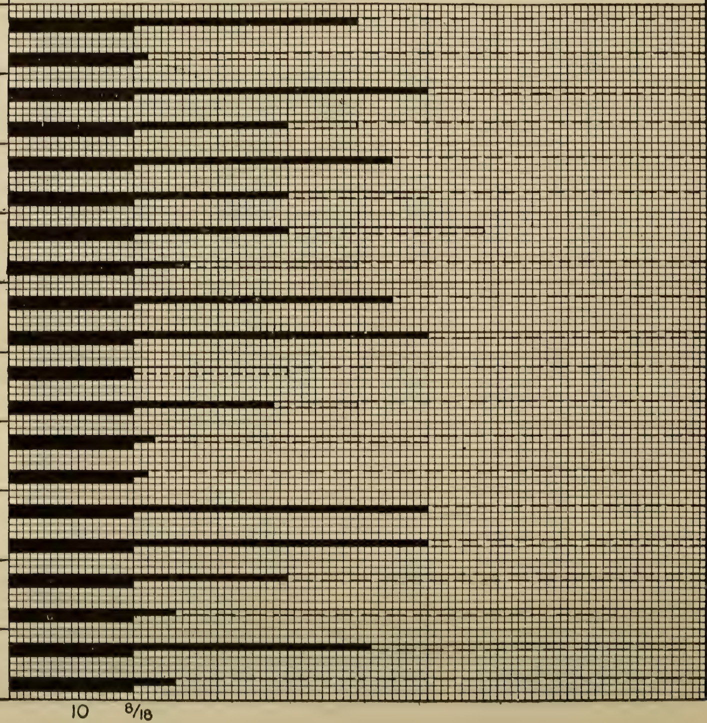


Figure 39. Material Control Sheet—Record in Areas

e Showing:

60 pieces ordered.	
36 pieces received,	24 still to come.
30 pieces ordered,	6 still to order.
20 pieces completed,	10 still to complete.
18 pieces ordered,	2 still to order.
12 pieces assembled,	6 still to assemble.

415 So much for the method of graphically controlling one part. The problem now becomes one of controlling several related parts as well as related sub-assemblies. In so doing, this thought must be kept in mind: *A record of what has passed is not particularly important; the record is good only in proportion as it anticipates or forecasts future conditions or likely happenings in time to arrange to prevent both shortages and congestion.*

416 The Material Control Record, Figure 39, is a graphic coördination of related units, using the method of graphic lines just described as a basis. It shows sequence as to parts from the standpoint of assembly, machining, and purchasing, and presents a true picture of graphic flow from which considerable can be realized in the way of usable facts. Assume that the purchasing agent, the machine-shop foreman and the assembly foreman get together and with this sheet make an effort to plan their work in a better manner. The assembly foreman will point out to the others that on parts 2, 8, 11, 13, 14, 18, 20, his margin between what has been assembled and the parts which could be assembled is so small as not to warrant him in attempting to assemble more units; in fact, he could not if he wanted to, as he has assembled all of part 11 that has been machined.

417 This puts it up to the machine foreman, who in looking over the sheet finds that while he has parts in order covering items 2, 8, 11, 13, 18, with materials to work on, and can therefore get behind these items, he has only enough parts on items 14 and 20 for two and six units, respectively. The purchasing agent, in looking over the sheets, finds that he must get busy, as material is all in for only four parts—3, 16, 18, 19—and material for 14 and 20

is urgently needed, as well as on parts 1, 5, 9, 15, as all the material on hand has been machined.

418 Sub-assemblies can also be listed on a separate sheet, the vertical line indicating final erection.

419 Some means should be provided for coördinating the element of *time* with that of *quantity*. A reference to Figures 38 and 39 will show that there were 10 large spaces, each space divided into 10 smaller spaces and each small space representing one piece, or 100 pieces in all. This being an excellent means of charting the condition as to pieces, sub-assemblies and final erection, it only remains to coördinate the time factor with the quantity factor, to make this method of charting complete. Figure 40 illustrates this coördination. The ten spaces representing quantity in Figures 38 and 39, *can also represent time in Figure 40,* and a direct relationship or schedule be established from which progress can be followed, as shown in the illustration (Figure 40).

420 In closing this chapter, a few words seem in order regarding the control of material from the accounting and cost angle, with special reference to stock records and storerooms. In many cases observed, considerable laxity existed, when as a matter of fact proper material accounting is just as important as labor accounting and accounting for cash on hand and in bank. The presentation will be made in the form of recommendations as outlined in a typical installation.

A The following are recommendations which are not new, as they have been made verbally and in writing covering a period of three months.

B These recommendations are made for the purpose of leaving with you a record of what we consider the proper and most effective method of handling the storing, recording, pricing and accounting for all materials, whether raw, partly finished, finished, partly assembled or assembled.

C These recommendations are based on one very important basic point, that the amount of money which you have tied up in stock materials, as well as in the materials in process of manufacture, is just as important to ac-

Dates	June 11	June 18	June 25	July 2	July 9	July 16	July 23	July 30	Aug. 6	Aug. 13
Working Days	6	12	18	24	30	36	42	48	54	60
Schedule of Pieces	10	20	30	40	50	60	70	80	90	100
Pieces Completed	2	8	18	20	20	50	80	85	100	
Pcs ahead of Sched.							10	5	10	
Pcs behind Sched.	8	12	12	20	30	10				
Completion Percentage on Schedule	20%	40%	60%	50%	40%	83%	114%	106%	111%	

FIGURE 40. METHOD OF COÖRDINATING TIME AND QUANTITY SCHEDULES

count for as are your accounts receivable, or the cash in the bank. Not only this, but in our opinion the custodian of anything of value, who has the responsibility of so handling the material in the process of manufacture as either to make a profit or to produce at a loss, is *not* the one to control the records governing same, either as to stock material or the material in process.

D In other words, when material is purchased, it is charged to one of two places: either to a storeroom where it is later to be accounted for by a requisition charging an expense or a productive order, or by an inventory showing it safely on hand; or directly to an expense account from the voucher register. In either case, a responsibility exists for the material.

E The Inventory accounts will be as per the actual physical units in the plant. Those in charge of each unit will be held strictly responsible for the material which is in each unit, which material is on record in detail of pieces in a stock record in the main office, and which stock record is an exact analysis of the controlling ledger accounts in the general ledger. The list of these storerooms, numbered as to accounts for the general ledger, is attached hereto.

F The organization of the material control was recommended, and is again recommended, as follows:

a All stock records of all material of all classes will be under the direct control of the finance manager as the company is at present organized. If the organization is changed by appointment of a comptroller, this duty would come under him.

b The stock record work would all be concentrated into one department under the supervision of a competent chief of stock records.

c In addition to this, there would be a supervisor of stores, who would have the responsibility for all storerooms. This responsibility would be particularly as to methods governing the work of the storerooms, as it is usually best for organization purposes to have the actual physical jurisdiction of the storekeepers vested in the division manager.

d The supervisor of stores, having control of all the outside functions, and the chief of stock records, having control of all inside functions as to the controlling of all records of all materials of all kinds, would produce results that would be coördinated to a complete degree.

e It will be distinctly understood that the object of the stock records is to provide properly the necessary information to any one who is in need of same. This means that the Production Department must be supported; that the Cost Department must be supported; and so also, the very important point of the purchasing. In fact, the only reason for keeping stock records is to supply proper information to every one along the line; and, in our opinion, the only way to accomplish this end is to concentrate all stock control functions under one head.

f Would it be considered correct to split the Cost Department into one for each division? Or the Payroll Department? Then why should the function of material control be split?

G As to details, there will be stock ledgers containing the detail of the material that is in each stock room, irrespective of whether this material is raw, partly finished, finished, partly assembled, or assembled. For instance, ... sent up from .... are in the Steel Store of the .... They are issued from here. It makes no difference in practice whether this particular material is labeled raw or partly manufactured, and there is not only no occasion to differentiate as between these, but there is every objection to so doing. These .... are *finished* material as far as .... is concerned, and *raw* material to the .... Same with forgings from the Forge Plant, and boxes from the Box Shop, and .... from .... in the ....

H As to explicit directions concerning the exact methods of giving to those who need it the benefits of the stock records, we will not attempt in this letter to specify. *Get the records running right, and the rest is easy.*

The importance of material control in industry seems to justify a fairly complete discussion, and it is hoped that it will receive the consideration it deserves, as one of the most important phases of Graphic Production Control.

Chapter XV

EQUIPMENT CONTROL

421 Industry should produce goods at standard cost, and the time will come when it will be forced to do so, either through competition, commercial clash between nations. or through wise economic legislation.

422 Is there any valid reason why an article should cost $5.50 to make, when a predetermined and fair standard indicates it can be made for $4? Is there any reason why the dear public, the consumer, should pay the difference between the actual cost and the standard cost, of $1.50, which represents waste or carelessness or inefficiency of some sort?

423 Will we ever get away from the high cost of living so long as prices include amounts in excess of what should be charged?

424 What makes for excessive costs or a cost greater than standard? Three elements:

Inefficiency of workmen.
Idle equipment.
Faulty shop practice.

425 If operations are standardized, if the flow of work is under control and idle time of equipment reduced to a minimum, it will be found that the inefficiency of the worker is not so large an item; in fact, if these things are done, any fair method of monetary reward will induce the support, interest and coöperation of the worker.

426 This brings us up to the matter of equipment.

427 It is the writer's opinion, based on experience extending over a period of years, that the greatest single inefficiency met with in industry is *idleness of equipment.* In fact, in four large and representative plants the idle time

of equipment was found to be 30 per cent., 35 per cent., 40 per cent. and 50 per cent., respectively.

428 Briefly stated, the reasons for this idleness in equipment are:

1 No work to do.

2 Breakdowns.

429 The function of a Control Department should be to devote as much time to controlling equipment as it does to controlling material. What good does it do to know what work is to be performed, and that material is on hand, only to find that a machine is out of order and either being repaired or awaiting repairs? What gain is there when, with plenty of work ahead, machines in perfectly good order are standing idle?

430 Equipment control is just as necessary as labor and material control; in fact, from a purely economic standpoint, equipment control is of even greater importance, for any failure to control equipment means labor idleness and a slower flow of material, therefore waste in time and money, resulting in excessive cost.

431 Let me outline a little more fully what I mean by the economic aspect of idleness.

432 Some years ago (1908) the author took hold of a large plant in Pennsylvania, comprising a structural shop, machine shop and foundry. The burden accounting at the time gave the machine shop more profits than it was entitled to, while the structural shop was showing profits less than those actually made. The foundry was selling castings to the machine shop and structural shop at actual cost, which did not include any proportion of the overhead expenses of the company. In the changes that followed, each department was put on its own feet through the books of the company, with provision for a monthly profit and loss statement.

433 The radical and, from the accounting standpoint, revolutionary thing about the development was the adoption of standard burden rates for the various departments, the work in process being charged with actual and credited with standard burden, the difference being charged or cred-

ited monthly to a departmental burden adjustment account. The theory which I had in mind then, and which is now being accepted by industrial managers, was that the greatest volume of business could be secured only when the plant was operating at about normal; that high production meant low costs, low production high costs, under the usual method of accounting. This meant that the selling and cost division came into conflict both when costs were high, which operated against getting business, and when costs were extremely low, due to abnormal business, which resulted in tenders lower than would be necessary to secure the business.

434 In other words, if a man had ten automatic machines in a department, with all of them busy, each would absorb one-tenth of the overhead and prices would be based accordingly, and these prices would be the normal or standard prices because the department would be working at practically full capacity. If suddenly, however, work should fall off so that only half of the machines could be kept busy, the prices, based on actual costs, with machines absorbing twice the regular overhead, would be so high as to operate against getting business with these machines. On the other hand, assuming that, through a sudden rush of orders, overtime, night and Sunday work, is resorted to, so that the ten machines would be turning out the work of twelve or fifteen, the costs, due to the smaller amount of overhead absorbed per machine, would be lower than a normal or standard price and the customer would get the benefit of this low price, when, as a matter of fact, the extra profit should be considered as an offset to the loss when the department is operating at less than capacity.

435 So much for the theory. How about the practice? A concern is in business to sell. It may make what it can sell or sell what it makes, but selling is the primary and fundamental basis of any business,—a principle which many accountants and industrial engineers alike seem to forget. Now then, if as a sales manager I cannot sell goods because, conditions being below normal, my prices are too high, due to excessive costs, or because, from an abnormally high production, my prices are lower than I know I can get for my goods, because of abnormally low costs, I do not need to be

an industrial engineer or an accountant to know that something is decidedly wrong with the whole thing, both in theory and in practice. In such cases the usual sales policy is to ignore cost figures and take business as judgment may dictate.

436 With standard rates, however, reflecting normal conditions, I am assured against loss in business on the one hand and loss in price and profits on the other. I know also that on this basis, a line which is profitable in the shop will show the profits in the costing, whereas during periods of low production the increased overhead rate will not only wipe out all profit, but make the line show a loss.

''Faulty practice,'' says the accountant; ''Poor business,'' says the manufacturer; ''Common sense,'' replies the engineer. At any rate, here is what happened to the concern in question. At the time the methods were introduced the business was making very little money. Its sales were not large. It was a heavy borrower, with a pattern account far in excess of the real value. It had a bond issue hanging over its head. To-day, this plant, with two additions, is doing a capacity business, making excellent profits and declaring dividends. It is discounting its paper as well as rapidly retiring its bonds, and the pattern account is where it belongs.

437 In other words, if a plant is operated at capacity, the product of its equipment will absorb all the overhead and the plant will be operating at normal, and, other things being equal, will get its share of the business to be had. If, on the other hand, the plant operates at one-half capacity, should all of the overhead be applied against that part of the product that is made? If five cows out of ten give milk, would you double the price of milk? If you did double the price, would you sell the milk? Have not the five cows produced a fair quantity of milk? Then why penalize them by increasing the cost of their production?

438 As one shop man puts it, ''I have a machine here which costs fifty cents per hour. If it operates one-half hour, why should I be charged $1 per hour for it? I am here, we have the men, the power, the material, and an organization to operate full time. If it works one-half the

time, is it my fault? Should not the other fifty cents per hour be borne by the business as an overhead charge, or by the sales department because it fails to give me sufficient work to do?

439 Was he so very far wrong in his reasoning?

440 In other words, standardize labor, machine and overhead rates and absorb differences between standard and actual costs in monthly adjustment accounts. What you do with the differences at the end of the year is no affair of mine, although my opinion is that they should be cleared through the profit and loss account. At any rate, what you have done is to place the differences where you can see them monthly instead of burying them in places from which there is no resurrection. Monthly analysis of the reasons for the differences is but a step to counteracting excesses in cost. If a person drinks to excess, or loafs to excess, or smokes or gambles to excess, the reward is both swift and certain. This is just as true of excess in idle equipment.

441 The most common causes of idleness are:

	Cause	*Remedy*
1	No operator.	Labor policy.
2	No material.	Material control.
3	Failure to schedule work.	Planning.
4	Waiting for set-up.	Planning.
5	Waiting for tools.	Planning.
6	Waiting for instructions.	Planning.
7	Waiting for drawings.	Planning.
8	Waiting for inspection.	Planning.
9	Waiting for materials.	Planning.
10	No work available.	Sales policy.
11	Breakdowns.	Anticipative inspection.
12	No power.	Anticipative inspection.

442 As there may be idleness on the part of workers as well as equipment, and as the first step in controlling idleness is knowing the amount of idle time and the reasons for it, this part of the work of controlling production should be as carefully organized as the work of controlling materials, as outlined in the previous paper.

443 A set of reports should be turned in each day, either

in the form of a time card or idleness record, covering the idle time of workers and machines. Different colors can be

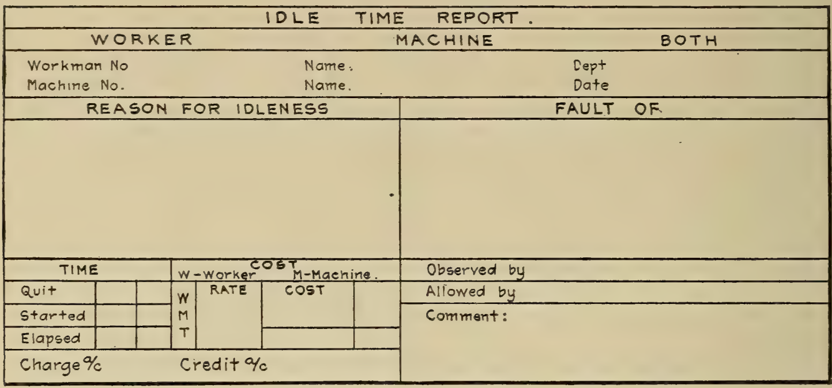

IDLE TIME REPORT.
WORKER | MACHINE | BOTH
Workman No | Name. | Dept
Machine No. | Name. | Date
REASON FOR IDLENESS | FAULT OF
TIME | COST W-Worker M-Machine. | Observed by
Quit | W M T | RATE | COST | Allowed by
Started | Comment:
Elapsed
Charge % | Credit %

FIGURE 41. IDLE TIME REPORT

used if time cards are adopted. If in the form of a record, the same card can be used for both worker and machine, as in Figure 41, the method of checking at the top showing what the record covers.

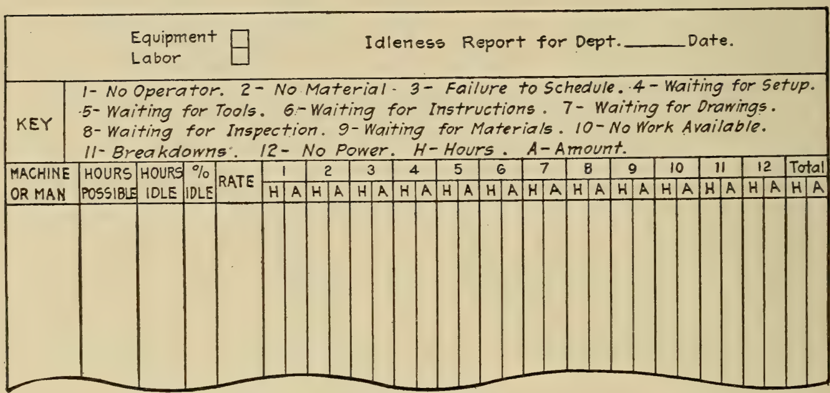

Equipment
Labor
Idleness Report for Dept.______Date.
KEY
1- No Operator. 2- No Material. 3- Failure to Schedule. 4- Waiting for Setup. 5- Waiting for Tools. 6- Waiting for Instructions. 7- Waiting for Drawings. 8- Waiting for Inspection. 9- Waiting for Materials. 10- No Work Available. 11- Breakdowns. 12- No Power. H- Hours. A- Amount.
MACHINE OR MAN | HOURS POSSIBLE | HOURS IDLE | % IDLE | RATE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Total
H A H A H A H A H A H A H A H A H A H A H A H A H A

FIGURE 42. CUMULATIVE IDLENESS REPORT FOR A MONTH

444 This can be filed daily according to worker or machine, and at the end of the month a recapitulation can be made out showing totals. A much better plan, however, is to make up a cumulative report daily (see Figure 42), as this would show tendencies during a month and often result

in betterments before the idleness became too great. The plan would be to add the second day's totals to those of the first day, the third day's totals to those of the second, and so on through the month. Any excessive idleness can in this way be watched daily, whereas by keeping cards until the end of the month for analysis, the information would show what had happened, not what is happening.

445 A separate report should be made for workers and for equipment, and at the end of the month a composite can be made out covering both. All sheets can be made out in

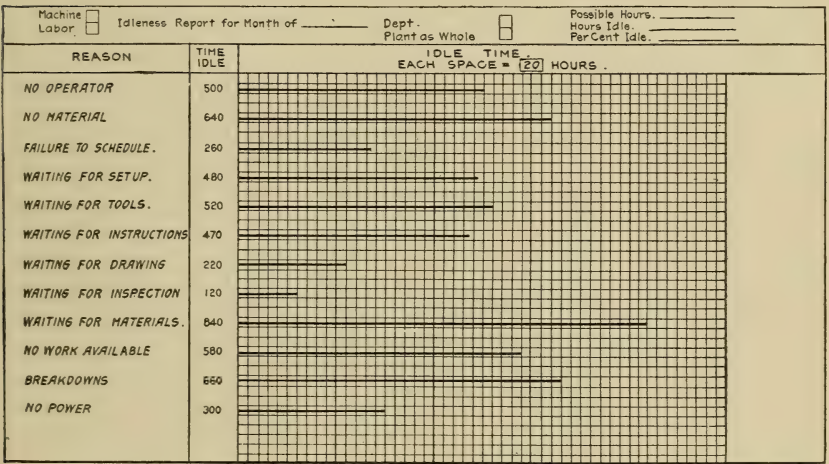


FIGURE 43. MONTHLY IDLENESS REPORT ANALYZED AS TO CAUSES

composite form for the entire plant. These composites can be shown graphically by departments or by the plant as a whole, as per Figure 43. Comparative statements can be easily prepared according to Figure 44.

446 A thoroughgoing knowledge of idle time and cost will result in a real study of limiting conditions, and steps will be found and taken to eliminate the causes.

447 ANTICIPATIVE INSPECTION. As one of the means for reducing idle time of equipment, the author urges a more systematic anticipative inspection than is usually found. When a locomotive comes in from a run, it is placed in the roundhouse and overhauled before going out on the next

run. It is this principle that the writer advocates in industry.

448 The aim of anticipative inspection is to—

A Minimize delays and breakdowns.
B Keep maintenance costs at a minimum.
C Secure greatest capacity from existing equipment.

449 It is one thing to take care of trouble when it occurs and another to anticipate it by days and sometimes weeks. This branch of the work should be organized along the following lines:

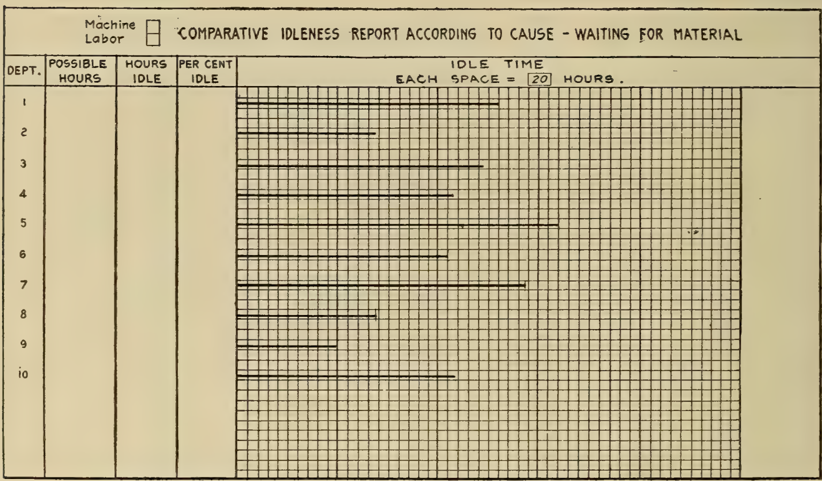


FIGURE 44. COMPARATIVE IDLENESS REPORT FOR A SINGLE CAUSE

A Each piece of equipment should be considered as a unit.

B As to each unit, the factors likely to cause trouble should be determined and provided for.

C Each unit should have a record card on which is recorded its complete history.

D For the various factors determined upon as requiring attention, limits as to time should be set for inspection purposes.

E Men should be delegated to look after this "anticipative inspection."

F These inspectors should be supplied with inspec-

tion reports, upon which to record their findings. These reports should be made out from the record cards covering the particular factors to be looked into, and sent to the inspectors. This would constitute an advance planning of this class of work.

G The inspectors should take the inspection reports, make the inspections called for, note the conditions, advise as to the troubles developing, and state what should be done and when.

H These reports should then be taken, and the information contained therein entered on the record cards.

I Repairs to the units as made should also be entered on the record cards, showing date and nature of the work done.

J Because the time limits at the start will be more or less arbitrarily determined, it will be found, as the work progresses, that many of them need adjustment. For instance, a factor may have a time limit of eight days, when every five days would be found to be the best limit. Another might have one of four days, and every two weeks be found sufficient. Adjustment of limits is simply a matter of analyzing the information shown on record cards.

K Delays should be recorded, investigated, and entries made on record cards, so as to make the information as comprehensive as possible.

L Cost of repairs should also be entered on record cards.

450 To assist the reader in getting a better idea of what is meant by anticipative inspection, an equipment record is illustrated in Figure 45. It shows the location and number of a machine, how often it should be inspected, its capacity and idle-time cost per hour. Across the top is a follow-up dating on which is placed a clip denoting when inspections are to be made. Each day the cards showing trips for the current day are referred to and schedules of inspection trips are given the inspectors. As they turn in reports, their findings are entered under "Troubles Found in Anticipative Inspections." As repairs are made, the date is

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

Form 4368—3·17—5M—17236

EQUIPMENT RECORD

MACHINE NO.	TYPE	DEPT.	BLDG.	FLOOR	SECT.
MACHINE TO BE INSPECTED EVERY		CHANGED TO EVERY		INSPECTORS NAME	
MACHINE CAPACITY				IDLE TIME COST PER HR.	

Troubles Found in Anticipative Inspection				Repair	Repair	Repairs Made			Idle Time		Repair
Date	Part	Nature	Cause	When	Started	Nature of Break	Cause	Nature of Repair	Hrs.	Cost	Cost

FIGURE 45. EQUIPMENT RECORD OF ANTICIPATIVE INSPECTION AND REPAIRS

entered under "Repairs Made." As can be seen by studying this record, if anticipative inspections are made faster than repairs, there will be more entries on the left-hand side of the record. If breaks and repairs happen at a faster rate than inspections, the greater will be the number of entries on the right-hand side. Inspection dates can be adjusted by comparing the two sides.

451 In the center the two columns "Repair When" and "Repairs Started" serve to furnish a basis for tying together the matter of anticipation and repair. At the extreme right hand are the costs, covering both idle-time costs and repair costs. The degree of attainment in anticipative inspection is the amount of reduction in these costs.

452 The Inspector's Report is shown as Figure 46, and it is from this that the entries to the Equipment Record are made. In other words, an inspector gets a schedule, makes an inspection and reports his finding, and these are transferred to the permanent record.

453 If desired, the Equipment Record can show the particular things which should receive the most attention, the basis of which is the determination of the factors likely to give the most trouble, and then having the inspector look after these factors regularly, in addition to the machine as a whole.

454 In this connection it is a good plan in some cases to have a utility man or gang of men whose function it is to go the rounds daily and look over the equipment for loose belts, faulty lubrication, worn bearings, shafting out of line, listening to motors, looking after cleanliness, etc. This not only facilitates the work of the regular inspectors, but is that much more done toward not only reducing idle-time but lessening maintenance costs. Many little things will be taken care of in these daily trips which would otherwise develop into serious breakdowns.

455 In keeping track of equipment it is necessary to know what is in hand and the information in connection therewith. Figure 47 illustrates the front and reverse sides of a "Machine Tool Record." In providing for new equipment, the "Equipment Requisition," Figure 48, is offered.

456 Standardization of Equipment. Anticipative in-

Form 4370—10-25-17—7240

Inspector's Daily Report by Departments Covering Machine Breakdowns and Machines Stopped for Repairs

DATE INSPECTOR DEPT.

Name of Machine	No.	Bldg.	Floor	Sect.	Machine Shut Down		Nature of Break or Repair	Cause of Break or Repair	Parts to be Replaced	Stock	Ordered	To be Ord.	Stop-Break	Action Taken	Promised to Finish	Actually Finished	
					Time	Date										Time	Date

FIGURE 46. INSPECTION RECORD OF MACHINES

spection as above outlined will do much to reduce idleness and cost of maintenance. As can be appreciated, however, a machine could be working full time and still operate at

MACHINE TOOL RECORD			DATE
MACHINE NO.	DEPT.	BLDG.	FLOOR
NAME OF MACHINE		MAKE OF TOOL	
WEIGHT-HEAVY-MEDIUM-LIGHT		DATE INSTALLED	

LINESHAFT	SIZE	D. OF PULLEY	FACE	R.P.M.
COUNTERSHAFT	SIZE	D. OF PULLEY	FACE	R.P.M.

		1	2	3	4	FACE		
DRIVING CONES	SIZE						POWER FEED	HAND FEED
							SPINDLE SPEED	
DRIVEN CONES	SIZE						STROKES PER MINUTE	
	R.P.M.						LENGTH OF STROKE	
DRIVING F. CONES	SIZE						RETURN RATIO	
DRIVEN F. CONES	SIZE						GRINDING TOOLS	MAN / TOOL ROOM
	R.P.M.						COOLING AGENT	

FEED CHANGE GEAR TRAIN

Figure 47. A Machine Tool Record

only 70 per cent. efficiency, because operating practice had not been standardized.

DRIVING BELT			S-D-T			APP. NO. PER DAY	
BELT POSITION						MATERIAL	
	SIZE	NO. TEETH	STEEL	SPEED	TEETH	PIECES MACHINED AT A TIME	
CUTTER					INSERTED / SOLID	NO. CUTTING TOOLS	
IF LATHE TOOL-SIZE OF STOCK						TOOLS GROUND EVERY	PIECES
KIND OF STEEL						TOOLS GROUND EVERY	HRS.
SHAPE OF TOOL			SQUARE	ROUND		IS WORK	RATTLED-PICKLED-SAND BLASTED
CUTTING SPEED-FT. PER MIN.						WORK MACHINED	
FEED-INCHES PER MIN.						NAME / PAT. NO.	
DEPTH OF CUT						ADDITIONAL DATA:	
WIDTH OF CUT							
METAL REMOVED PER MINUTE							

Figure 47a. Reverse of Machine Tool Record Shown in Figure 47

457 The elements, in addition to the equipment, the standardization of which has been considered previously in this and other chapters, are—

Speeds and feeds. Belt practice.
Tools. Special practice.

458 Instead of here outlining the methods to pursue in standardizing, we will show a number of graphic standardization records, Figures 49 to 69, worked out in one case;

and while the data will not apply in all cases, the charts will act as guides in putting this important work on a much better basis.

459 Too much attention cannot be given to this impor-

EQUIPMENT REQUISITION

COVERING

MOULDING MACHINES ☐ CORE BOXES ☐
METAL PATTERNS ☐ JIGS AND TOOLS ☐
MATCH PLATES ☐

FOR DEPT. DATE

MAKE

FOR USE ON

PRESENT COST OF DOING ONE PIECE		IS WORK SPECIFIED	STANDARD / SPECIAL
EXPECTED SAVING PER PIECE		IS DESIGN LIKELY TO BE DISCONTINUED	YES / NO
APPROXIMATE NO. PIECES YEARLY		IF YES WHEN	HOW MANY PCS. IN MEANTIME
YEARLY SAVING		DO YOU FAVOR DOING ABOVE	YES / NO
EST. COST LABOR		REQUISITIONED BY	
" " MATERIAL		APPROVED BY	DATE
LABOR + MAT. TOTAL		STARTED	FINISHED

FIGURE 48. FORM FOR EQUIPMENT REQUISITION

tant work of standardization of equipment, tools and special practice. It is found in many instances that workmen grind their own tools; that the shape of the tool is a matter of the individual experience of the one who may have the say at the time as regards the sizes, shapes and angles; the matter

of belt positions and motor speeds is left to those who, while having a certain amount of experience in determining speeds and feeds, may and oftentimes are not using what is the best practice. The eighth law of Graphic Production Control, Chapter VI, if at all logical, is grossly violated when the above is allowed. It is of course true that practice varies in different plants, and the claim is not made that a standard determined for one kind of work in one

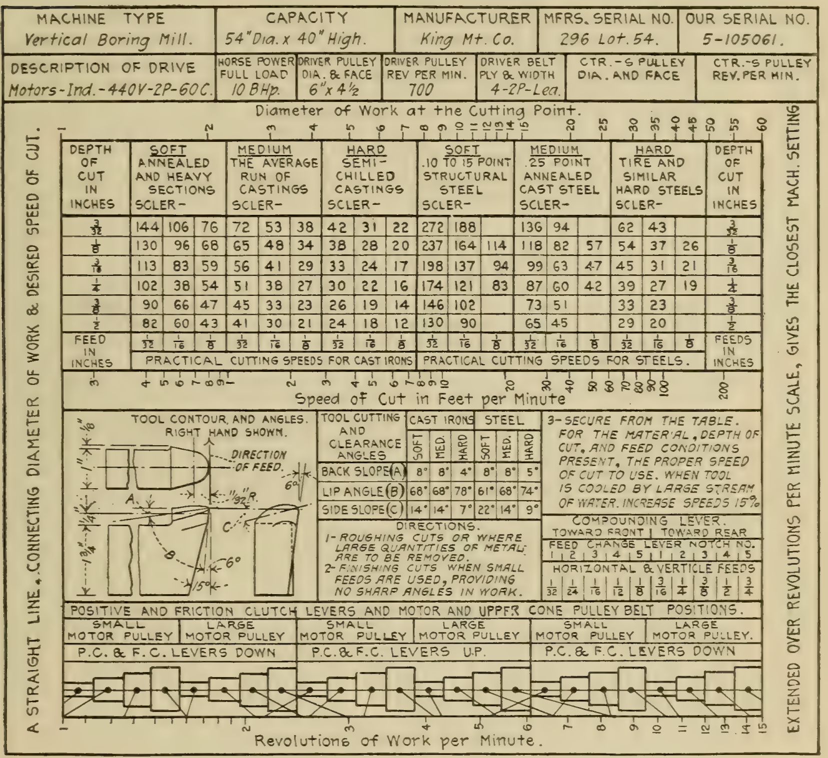
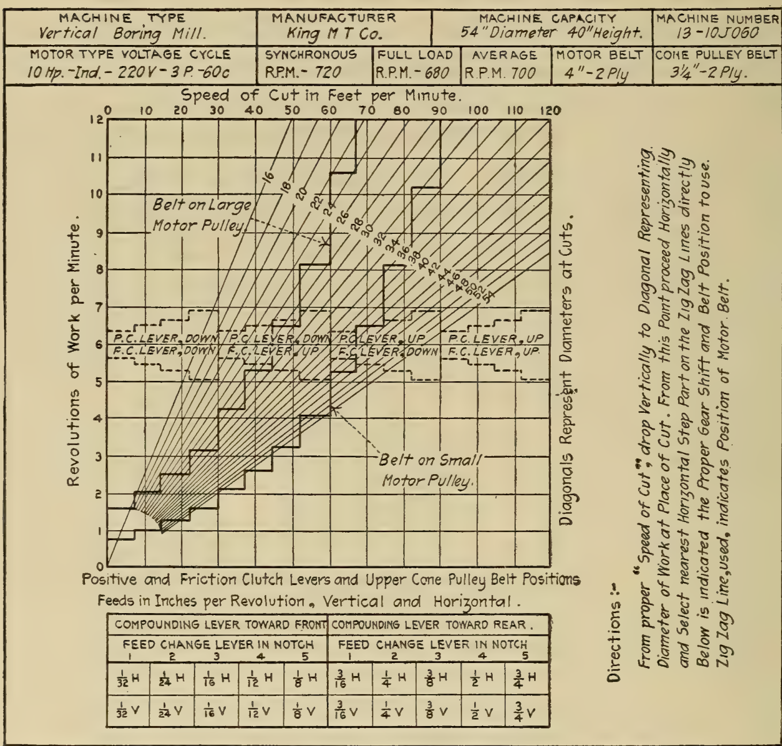


FIGURE 49. FEEDS AND SPEEDS WITH MACHINE SETTING FOR A VERTICAL BORING MILL

plant, will cover the same kind of work in all other plants. The claim is made however that a great deal more in the way of results can be accomplished in a given plant if attention is paid to this important branch of increasing production.

460 A division of "Speeds and Feeds" can well be es-

tablished in connection with a betterment program. Some man in the plant whose hobby has been and is the study of speeds, tools, machines and the like, can be placed in charge to work with and under the Control Department. He should be required to read and study, if he has not already done so, the works of Taylor, Barth and others, on this subject of standardization of speeds and feeds and tools. Tests should be made as to the different kinds of cutting steels and tools

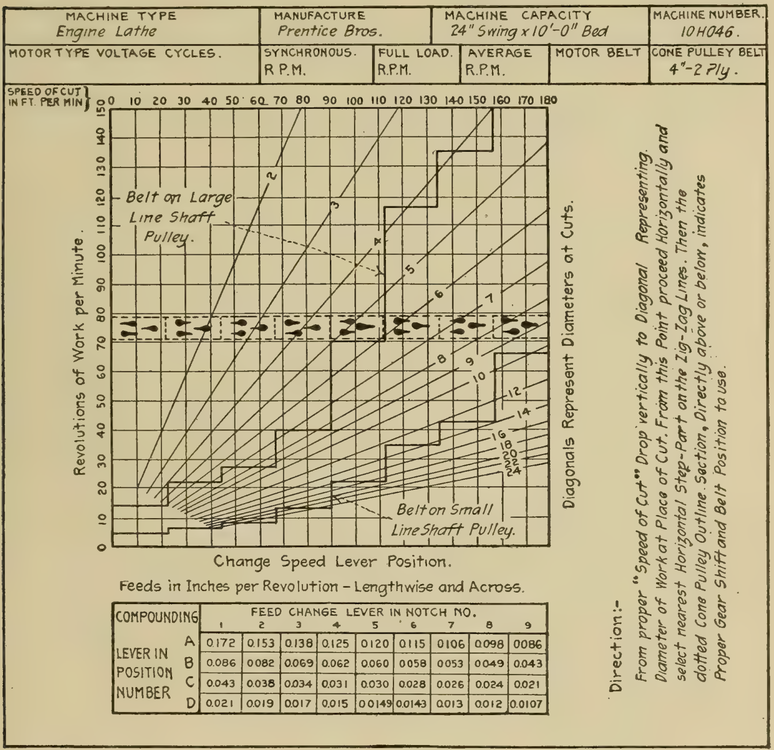


COMPOUNDING LEVER TOWARD FRONT					COMPOUNDING LEVER TOWARD REAR.				
FEED CHANGE LEVER IN NOTCH					FEED CHANGE LEVER IN NOTCH				
1	2	3	4	5	1	2	3	4	5
$\frac{1}{32}$ H	$\frac{1}{24}$ H	$\frac{1}{16}$ H	$\frac{1}{12}$ H	$\frac{1}{8}$ H	$\frac{3}{16}$ H	$\frac{1}{4}$ H	$\frac{3}{8}$ H	$\frac{1}{2}$ H	$\frac{3}{4}$ H
$\frac{1}{32}$ V	$\frac{1}{24}$ V	$\frac{1}{16}$ V	$\frac{1}{12}$ V	$\frac{1}{8}$ V	$\frac{3}{16}$ V	$\frac{1}{4}$ V	$\frac{3}{8}$ V	$\frac{1}{2}$ V	$\frac{3}{4}$ V

FIGURE 50. FEEDS AND SPEEDS WITH MACHINE SETTING FOR A VERTICAL BORING MILL

for the work to be performed in a given plant, to determine the best material, which should then be purchased. Tests should be made as to the places where machine practice can be improved, in cones, bearings, heads, rests, beds, tool holders, stocks and clamps. Work to do should then be considered and tests made to determine range and limits for steel and cast iron (soft, medium and hard) as to depth

of cut and feed, according to the speeds obtainable from the equipment. The matter of forging, tempering and grinding of tools and their angles and clearances should also be considered, all of which will mean a valuable file of standard practice. This brings us up to the matter of the proper presentation and control of this data, and in this connection our feeling is that the graphic plan is the best, the practice



COMPOUNDING LEVER IN POSITION NUMBER	FEED CHANGE LEVER IN NOTCH NO. 1	2	3	4	5	6	7	8	9
A	0.172	0.153	0.138	0.125	0.120	0.115	0.106	0.098	0.086
B	0.086	0.082	0.069	0.062	0.060	0.058	0.053	0.049	0.043
C	0.043	0.038	0.034	0.031	0.030	0.028	0.026	0.024	0.021
D	0.021	0.019	0.017	0.015	0.0149	0.0143	0.013	0.012	0.0107

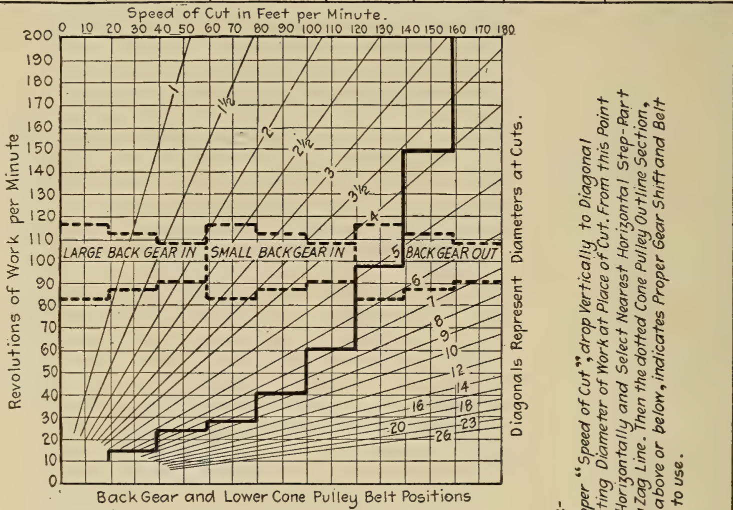
FIGURE 51. FEEDS AND SPEEDS TOGETHER WITH BELT POSITION AND MACHINE SETTING FOR AN ENGINE LATHE

to be reduced to standard size prints, to be mounted on metal plates, behind celluloid sheets, and placed at machine where workmen can see the standard practice and be governed accordingly. These can also act as a guide to the one in charge of this important work, who in going from place to place can see not only that the work is being made as per the standards set but direct and train the workers as to this practice.

461 Systematic handling of maintenance and construction, the moving of equipment, and the replacement of small tools, are so essential to a proper control of equipment that it seemed fitting to outline a typical procedure which would serve to indicate the nature of the steps to follow.

FEEDS AND SPEEDS OBTAINABLE

MACHINE TYPE	MANUFACTURER		MACHINE CAPACITY		MACHINE CAPACITY
Engine Lathe	*Schmacher & Boye.*		*26" Swing x 12'-0" Bed.*		*10H047*
MOTOR TYPE VOLTAGE CYCLE	SYNCHRONOUS R.P.M.	FULL LOAD R.P.M.	AVERAGE R.P.M.	MOTOR BELT	CONE PULLEY BELT



Feeds in Inches per Revolution - Lengthwise and Across

COMPOUNDING LEVER IN POSITION NUMBER	Feed Change Lever in Notch Number. 1	2	3	4	5	6	7	8
1	0.200	0.1777	0.160	0.1455	0.139	0.1334	0.1231	0.1142
2	0.100	0.1888	0.080	0.0727	0.0696	0.0666	0.0615	0.0572
3	0.050	0.1444	0.040	0.0364	0.0348	0.0333	0.0308	0.0285
4	0.025	0.1222	0.020	0.0182	0.0174	0.0166	0.0154	0.0143
5	0.0125	0.0111	0.010	0.0091	0.006	0.0083	0.0077	0.0071

FIGURE 52. FEEDS AND SPEEDS WITH GEAR POSITIONS AND MACHINE SETTING FOR AN ENGINE LATHE

462 MAINTENANCE ORDERS.

Purpose of Method: To provide a means of requisitioning on the Maintenance Department for repair work or any minor work to be done for the company, which when completed does *not* appear on the books as an asset.

463 METHOD HANDLED BY—

1 Foremen, or other employees in authority.

2 Supervisor of production.
3 Supervisor of maintenance.
4 Maintenance foremen.

464 Procedure in Handling:

1 When repairs or any minor work may be required, the foreman of the department requiring the work, or any employee in authority, shall make out a Maintenance Order in three copies.

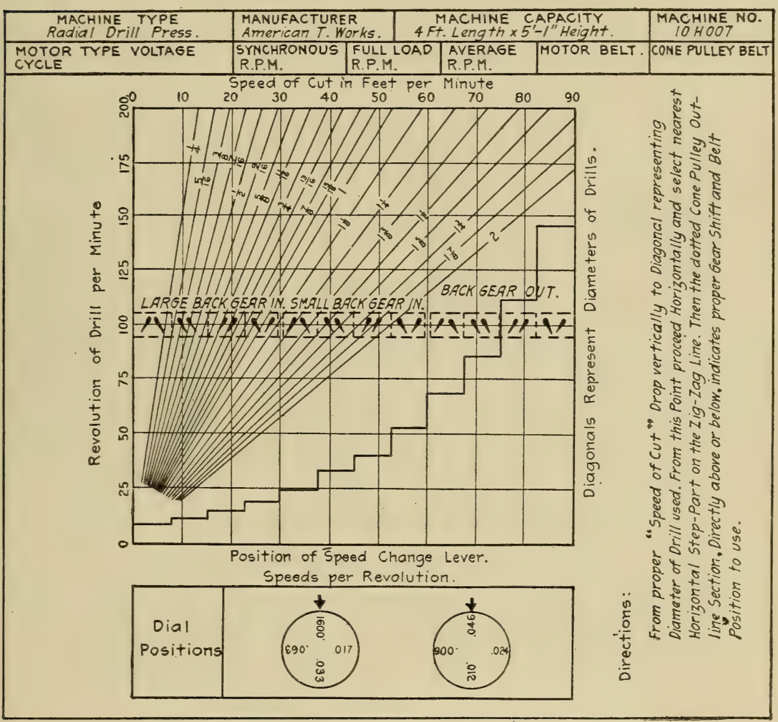


Figure 53. Feeds and Speeds with Machine Setting for a Radial Drilling Machine

2 The Maintenance Order shall contain the following information: Serial number, department issuing, charge to operation number, date issued, date wanted, machine number (if repair to machine), location of job, nature of work to be done, and signature of the foreman.

3 If the nature of the repair is such that the machine

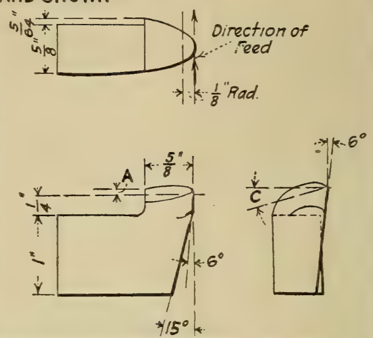
can still operate without an immediate repair, the Maintenance Order must be approved by the supervisor of production, to ascertain whether the machine can be spared from production.

4 One copy shall be given to the foreman who is to make the necessary repair, one copy shall be sent to the

FEED AND SPEEDS TO USE WITH TOOL SPECIFIED BELOW

DEPTH OF CUT INCHES	FEED IN INCHES	CAST IRON SOFT AN'L'D & HEAVY SECTIONS	CAST IRON MED. AVERAGE RUN OF CASTINGS	CAST IRON HARD SEMI-CHILLED CASTINGS	STEEL SOFT .10-.15 CARBON STEEL	STEEL MED. AN'L'D CAST ST. .45 CARB	STEEL HARD TIRE & SIMILAR HARD STEELS
$\frac{1}{16}$	$\frac{1}{64}$				428.8	214.4	97.6
	$\frac{1}{32}$				280.0	140.0	63.6
	$\frac{1}{16}$				183.2	92.0	41.6
$\frac{3}{32}$	$\frac{1}{64}$	171.2	85.6	49.8	364.8	182.4	83.2
	$\frac{1}{32}$	126.4	63.1	36.8	239.2	119.2	54.3
	$\frac{1}{16}$	88.0	43.9	25.6	156.0	78.1	35.5
	$\frac{3}{32}$	69.6	34.9	20.4	121.6	60.9	27.6
$\frac{1}{8}$	$\frac{1}{64}$	158.4	79.2	46.1	328.0	164.0	74.4
	$\frac{1}{32}$	116.8	58.4	34.0	214.4	107.2	48.7
	$\frac{1}{16}$	81.6	40.6	23.7	140.0	70.0	31.8
	$\frac{3}{32}$	65.4	32.3	18.8	109.6	54.7	24.8
	$\frac{1}{8}$	54.7	27.3	16.0			
$\frac{3}{16}$	$\frac{1}{64}$	143.2	71.5	41.6	280.8	140.8	63.9
	$\frac{1}{32}$	105.6	52.7	30.7	184.0	92.0	41.7
	$\frac{1}{16}$	773.4	36.7	21.4	120.8	60.5	27.5
	$\frac{3}{32}$	58.4	29.2	17.0			
	$\frac{1}{8}$	49.4	24.7	14.4			
	$\frac{1}{}$						
$\frac{1}{4}$	$\frac{1}{64}$	133.6	66.7	38.9	255.2	128.0	58.0
	$\frac{1}{32}$	98.4	49.2	28.7	167.2	84.0	38.0
	$\frac{1}{16}$	68.4	34.2	20.0			
	$\frac{3}{32}$	84.4	27.2	15.9			
	—						
$\frac{3}{8}$	$\frac{1}{64}$	121.6	60.8	35.4	224.0	112.0	50.8
	$\frac{1}{32}$	89.6	44.8	26.1			
	$\frac{1}{16}$	62.4	31.2	18.1			
	—						
	—						

TOOL CONTOUR AND ANGLES, RIGHT HAND SHOWN



TOOL CUTTING ANGLES	CAST IRON SOFT	CAST IRON MED.	CAST IRON HARD	STEEL SOFT	STEEL MED	STEEL HARD
BACK SLOPE A	8°	8°	4°	8°	8°	5°
LIP ANGLE B	.68°	68°	78°	61°	68°	74°
SIDE SLOPE C	.14°	.14°	7°	22°	14°	9°
SCLEROSCOPE HARDNESS FOR MATERIAL						

WORK FOR WHICH THIS TOOL IS ADAPTED

1. Roughing Cuts
2. Finishing Cuts when Small Feeds are Used.
3. Feed Toward the Left with R.H. Tool and Toward the Right with L.H. Tool.
4. Should be Used Mainly where a Long and Heavy Cut is Necessary.
5. Not Adapted for Finishing Work which Requires Sharp Angles in Contours.
6. When Tool is Cooled by a Large Stream of Water, Increase Cutting Speeds by 15 Per Cent.

Figure 54. Feeds and Speeds in both Cast Iron and Steel for 5/8-Inch Round Nose Roughing Tool

Maintenance Office (this copy may be sent through the mail), and the third copy shall be retained by the person ordering.

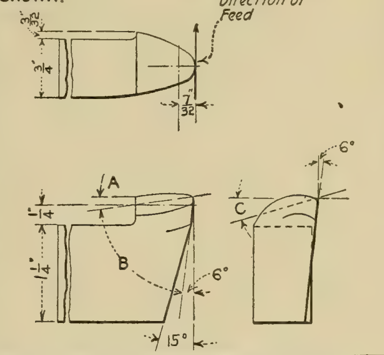
5 No work shall be performed by the Maintenance Department unless the work to be done is ordered in writing on a Maintenance Order.

6 The foreman doing the work shall file his orders in a rack showing those orders being worked on, orders ready to be worked on, and orders delayed for material. As soon as the orders are completed they shall be pulled from the rack, the date finished entered and then stamped

FEED AND SPEEDS TO USE WITH TOOL SPECIFIED BELOW

Depth of Cut in Inches	Feed in Inches	Cast Iron: Soft A'n'ld and Heavy Sections	Cast Iron: Med. Average Run of Castings	Cast Iron: Hard Semi-Chilled Castings	Steel: Soft .10–.15 Carbon Steel	Steel: Med A'n'ld Cast Steel .45 Carb.	Steel: Hard Tire & Similar Hard Steels
1/16	.015						
	.031						
	.047						
3/32	.031	174.4	80.0	50.8	372.2	186.4	84.8
	.062	12.64	66.0	38.4	167.2	84.0	38.0
	.025	94.4	47.1	27.5			
1/8	.031	160.0	79.8	46.5	330.0	165.6	75.1
	.041	120.8	60.4	35.2	221.6	111.2	50.5
	.062	86.4	43.1	25.1	148.8	74.3	33.7
	.083	69.6	34.8	20.3	117.6	58.8	26.7
	.125	59.5	29.7	17.3	98.4	49.2	22.4
	.187	47.5	23.8	13.9			
3/16	.031	141.6	70.9	41.3	280.0	140.0	63.6
	.041	107.2	53.6	31.2	188.0	94.4	42.7
	.062	76.5	38.3	22.3	125.6	63.0	28.6
	.083	61.7	30.8	18.0	100.0	49.9	22.6
	.125	52.8	26.4	15.4			
	.187	42.3	21.1	12.3			
1/4	.031	131.2	65.5	38.2	250.0	125.6	56.9
	.041	99.2	49.5	28.8	168.0	84.0	38.2
	.062	70.7	35.3	20.6			
	.083	57.0	28.5	16.6			
	.125	48.8	24.4	14.2			
3/8	.031	117.6	58.8	34.3	215.2	108.0	49.0
	.041	88.8	44.4	26.0	144.8	72.3	3.28
	.062	63.4	31.6	18.4			
	.083	51.2	25.6	14.9			
	.125						

TOOL CONTOUR AND ANGLES, RIGHT HAND SHOWN.



Tool Cutting Angles	Cast Iron: Soft	Cast Iron: Med	Cast Iron: Hard	Steel: Soft	Steel: Med.	Steel: Hard
Back Slope A	8°	8°	4°	8°	8°	5°
Lip Angle B	68°	68°	78°	61°	68°	74°
Side Slope C	14°	14°	7°	22°	14°	9°
Scleroscope Hardness for Material						

WORK FOR WHICH THIS TOOL IS ADAPTED

1. Roughing Cuts.
2. Finishing Cuts when Small Feeds are Used.
3. Feed Toward the Left with R.H. Tool, and Toward the Right with L.H. Tool
4. Should be Used Mainly where a Long and Heavy Cut is Necessary.
5. Not Adapted for Finishing Work which Requires Sharp Angles in Contours.
6. When Tool is Cooled by a Large Stream of Water, Increase Cutting Speeds by 15 Per Cent.

FIGURE 55. FEEDS AND SPEEDS IN BOTH CAST IRON AND STEEL FOR ¾-INCH ROUND NOSE ROUGHING TOOL

"Completed." Once every day all completed orders shall be returned to the Maintenance Office.

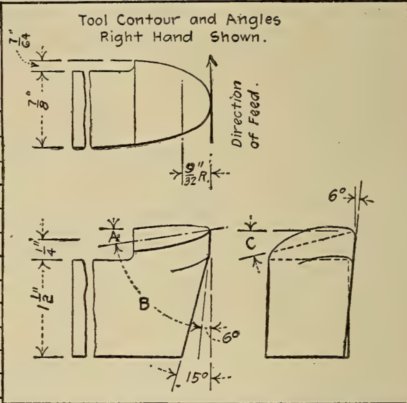
7 The Maintenance Office copy of orders shall be filed numerically according to serial number. When the foreman's copy is received, showing that the work is finished, the order in the file shall be removed and filed by depart-

ment and machine number. The copy returned by the foreman shall now be destroyed.

8 The supervisor of maintenance shall go over these orders periodically and, where repairs are running heavy on a particular machine and the nature of the repair is the same, it shall be his duty to devise some way of anticipating these breakdowns.

FEEDS AND SPEEDS TO USE WITH TOOL SPECIFIED BELOW

DEPTH OF CUT IN INCHES:	FEED IN INCHES	CAST IRON			STEEL		
		SOFT A'N'L'D & HEAVY SECTIONS	MED. AVERAGE RUN OF CASTING	HARD SEMI-CHILLED CASTINGS	SOFT .10 - 15 CARBON STEEL	MED. A'N'L'D CAST STEEL 45 CARBON	HARD TIRE & SIMILAR HARD STEELS
3/34	.031	137.6	68.8	40.1	26.0	130.4	59.1
	.062	97.6	44.8	28.4	177.6	88.8	40.3
	.125	70.1	35.1	20.4			
1/8	.031	125.6	62.8	36.6	228.8	114.4	52.0
	.062	89.6	44.6	26 0	156.0	78.2	35.5
	.125	64.1	32.0	18.7	106.4	53.3	24.2
3/16	.031	142.4	71.1	41.5	192.0	96.0	43.6
	.041						
	.062	80.0	40.0	23.3	131.2	65.6	29.8
	.083						
	.125	55.8	27.9	16.3	89.6	44.7	20.3
	.187	45.1	22.5	13.2			
1/4	.031	100.0	50.0	29.2	170.4	84.8	38.7
	.041						
	.062	172.7	36.4	21.2	116.0	58.0	26.4
	.083						
	.125	51.1	25.5	14.8			
	.181	41.2	20.6	12.0			
3/4	.031	88.8	44.4	25.9	144.8	72.2	32.8
	.041						
	.062	64.4	32.2	18.8	98.4	49.2	22.4
	.083						
	.125	45.3	22.6	13.2			
1/2	.031	81.6	40.8	23.8	129.6	64.6	29.3
	.041						
	.062	59.3	29.6	17.3			
	.083						
	.125	41.7	20.8	11.9			



TOOL CUTTING ANGLES.	CAST IRON			STEEL		
	SOFT	MED.	HARD	SOFT	MED.	HARD
BACK SLOPE A.	8°	8°	4°	8°	8°	5°
LIP ANGLE B.	68°	68°	78°	61°	68°	74°
SIDE SLOPE C	14°	14°	7°	22°	14°	9°
SCLEROSCOPE HARDNESS FOR MATERIAL						

WORK FOR WHICH THIS TOOL IS ADAPTED.

1 - *Roughing Cuts.*
2 - *Finishing Cuts when small Feeds are used.*
3 - *Feed toward the left with R.H. Tool, and towards the Right with L.H. Tool.*
4 - *Should be used Mainly where a long and heavy Cut is used.*
5 - *Not adapted for Finishing Work which Requires Sharp Angles in Contours.*
6 *When Tool is Cooled by a large Stream of Water, increase cutting Speed 15 %.*

Figure 56. Feeds and Speeds in both Cast Iron and Steel for 7/8-Inch Round Nose Roughing Tool

465 Construction Orders.

Purpose of Method: To provide a means of ordering new construction work, dies, jigs, fixtures, and tools of such a nature that they will appear on the books of the company as an asset when finished.

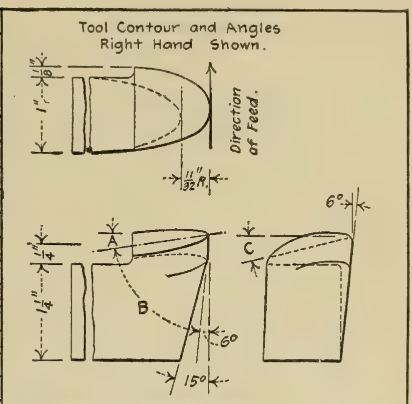
466 Method Handled by—

1 Foreman of department requiring work, or other employee in authority.

2 Supervisor of maintenance for new construction work.

3 Supervisor of production for jigs, fixtures, and dies.

Depth of Cut in Inches.	Feed in Inches.	Cast Iron			Steel		
		Soft A'N'L'D & Heavy Sections	Med. Average Run of Casting	Hard Semi-Chilled Castings	Soft .10–15 Carbon Steel	Med. A'N'L'D Cast Steel .45 Carbon	Hard Tire & Similar Hard Steels
3/32	1/32	144.0	72.1	42.2	272.0	1360	61.7
	1/16	106.4	53.1	30.9	188.0	94.4	428
	1/8	75.6	37.7	22.0	—	—	—
1/8	1/32	129.6	64.9	379	236.8	118.4	538
	1/16	96.0	47.8	27.9	164.0	81.6	37.2
	1/8	68.0	34.0	19.8	113.6	56.8	25.8
3/16	1/64	144.9	72.4	42.4	285.2	143.0	64.9
	1/32	112.8	56.4	32.8	197.6	99.2	44.9
	1/16	83.2	41.4	211.1	136.8	63.4	31.1
	3/32	68.0	34.0	20.0	110.2	55.2	25.2
	1/8	59.0	295	17.2	94.4	474	215
	3/16	48.0	24.0	14.0	.763	381	17.3
1/4	1/64	141.2	65.6	38.4	251.0	125.4	57.2
	1/32	102.4	51.2	29.8	174.4	872	39.5
	1/16	37.6	376	220	120.8	60.2	273
	3/32	61.9	30.9	18.1	96.8	539	22.0
	1/8	53.6	26.8	156	83.2	416	18.9
	3/16	43.6	22.2	12.7	—	—	—
3/8	1/64	115.0	57.6	336	2120	106.2	48.2
	1/32	89.6	44.9	26.2	146.4	73.5	33.4
	1/16	66.1	33.1	19.2	1016	50.8	23.1
	3/32	54.4	28.2	158	816	409	186
	1/8	471	23.5	137	—	—	—
1/2	1/64	1055	528	307	1875	935	42.4
	1/32	824	41.4	240	1296	64.7	29.4
	1/16	604	302	17.6	896	44.7	203
	3/32	49.5	248	14.4	—	—	—
	1/8	430	215	125	—	—	—



Tool Cutting Angles.	Cast Iron			Steel		
	Soft	Med.	Hard	Soft	Med.	Hard
Back Slope A.	8°	8°	4°	8°	8°	5°
Lip Angle B.	68°	68°	78°	61°	68°	74°
Side Slope C	14°	14°	7°	22°	14°	9°
Scleroscope Hardness for Material						

WORK FOR WHICH THIS TOOL IS ADAPTED.

1- Roughing Cuts.
2- Finishing Cuts when small Feeds are used.
3- Feed toward the left with R.H. Tool, and towards the Right with L.H. Tool.
4- Should used mainly where a long and heavy Cut is necessary.
5- Not adapted for Finishing Work. Requires Sharp Angles in Contour.
6 When Tool is Cooled by a large Stream of Water, increase cutting Speed 15%.

Figure 57. Feeds and Speeds in both Cast Iron and Steel for 1-Inch Round Nose Roughing Tool

4 Cost Department.

5 General manager.

6 Foreman who is to do the work.

467 Procedure in Handling:

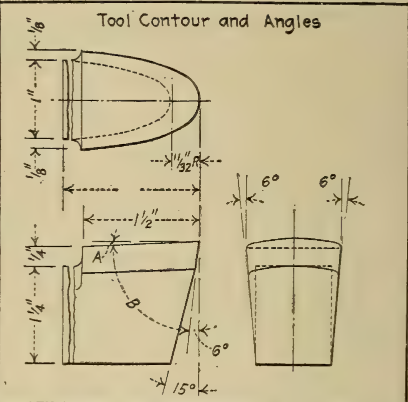
1 Requisition for Construction.

a Whenever any new construction work or any new

tools, jigs, fixtures or dies which when completed shall appear on the books of the company as an asset are required, a Requisition for Construction shall be made out in duplicate by the foreman or by any employee in authority, showing the date, the exact nature of the work desired, and by whom issued.

b One copy shall be retained by the person issuing as a record, and the other copy sent to the supervisor

DEPTH OF CUT IN INCHES	FEED IN INCHES	CAST IRON SOFT A'N'L'D & HEAVY SECTIONS	CAST IRON MED. AVERAGE RUN OF CASTINGS	CAST IRON HARD SEMI-CHILLED CASTINGS	STEEL SOFT .10-.15 CARBON STEEL	STEEL MED. AN'L'D CAST STEEL .45 CARBON	STEEL HARD TIRE & SIMILAR HARD STEELS
3/32	1/32	135.0	67.6	39.5	255.0	127.5	57.9
	1/16	81.7	40.9	23.8	176.2	88.5	40.1
	1/8	70.8	35.4	20.7			
1/8	1/32	155.2	60.9	35.5	222.0	111.0	50.4
	1/16	90.0	44.8	26.1	153.7	76.5	34.9
	1/8	63.8	31.8	18.6	106.5	53.2	24.2
3/16	1/32	105.7	52.8	30.8	185.2	93.0	42.1
	1/64						
	1/16	78.0	38.8	22.6	128.2	64.2	29.1
	1/12						
	1/8	55.3	27.6	16.1	89.2	44.4	20.1
	3/16	45.0	22.5	13.1	71.5	35.7	16.2
1/4	1/32	96.0	48.0	27.9	163.5	81.7	37.0
	1/24						
	1/16	70.6	35.3	20.6	113.2	56.4	25.6
	1/12						
	1/8	50.3	25.1	14.7	78.0	39.0	17.7
	3/16	40.9	20.8	11.9			
3/8	1/32	84.0	42.1	24.6	137.2	68.9	31.3
	1/24						
	1/16	62.0	31.0	18.0	95.2	47.7	21.6
	1/12						
	1/8	44.1	22.0	12.9			
1/2	1/32	77.2	38.5	22.5	121.5	60.6	27.6
	1/24						
	1/16	56.7	28.3	16.5	84.0	41.9	19.0
	1/12						
	1/8	40.3	20.1	11.7			



TOOL CUTTINGS ANGLES	CAST IRON SOFT	CAST IRON MED.	CAST IRON HARD	STEEL SOFT	STEEL MED.	STEEL HARD
BACK SLOPE A.	12°	12°	6°	14°	12°	7°
LIP ANGLE B.	82°	82°	88°	80°	82°	89°
SIDE SLOPE C	0	0	0	0	0	0
SCLEROSCOPE HARDNESS FOR MATERIAL						

WORK FOR WHICH THIS TOOL IS ADAPTED.

1- *Roughing Cuts.*
2- *Feed by Hand.*
3- *Feeds in Either Direction.*
4- *Should be Mainly used for Roughing out Metal where Work is Divided between Cutting on Sides and Bottom of Cavity-Such as a Tire Mould.*
5 *Not adapted for Work requiring Sharp Angles in Contour.*

FIGURE 58. FEEDS AND SPEEDS IN BOTH CAST IRON AND STEEL FOR 1-INCH SPECIAL ROUND NOSE ROUGHING TOOL

of maintenance if for new construction work, and to the supervisor of production if for tools, jigs, fixtures, or dies.

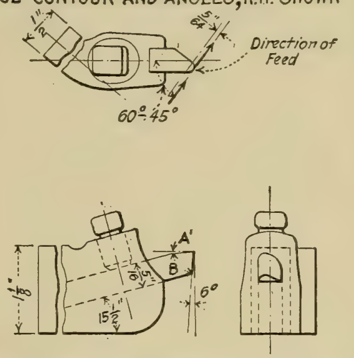
c The supervisor of maintenance or of production, as the case may be, shall approve it if he deems the

work necessary, and forward the requisition to the Cost Department.

d The Cost Department shall obtain the approval of the general manager on new construction work and then attach the requisition to the Cost Department copy of the Construction Order, which shall be made out as follows:

DEPTH OF CUT IN INCHES	FEED IN INCHES	CAST IRON: SOFT AN'L'D AND HEAVY SECTIONS	CAST IRON: MED. AVERAGE RUN OF CASTINGS	CAST IRON: HARD SEMI-CHILLED CASTINGS	STEEL: SOFT .10-.15 CARBON STEEL	STEEL: MED. AN'L'D CAST STEEL .45 CARBON	STEEL: HARD TIRE AND SIMILAR HARD STEELS
1/16	1/64				350.0	175.0	79.8
	1/32				221.0	110.0	50.5
	1/16				139.3	70.0	31.7
3/32	1/64	146.3	72.8	42.6	297.5	152.6	69.3
	1/32	103.6	54.4	30.1	192.5	95.9	43.8
	1/16	69.4	34.7	20.2	121.1	60.6	27.5
	3/32	53.9	26.9	15.3	92.4	46.2	21.0
1/8	1/64	137.9	68.8	40.1	277.0	138.6	83.0
	1/32	97.3	48.5	28.3	175.0	87.5	39.7
	1/16	65.3	32.6	19.1	110.0	55.1	25.0
	3/32	50.7	25.4	14.8			
	1/8	42.8	21.4	12.3			
3/16	1/64	126.7	63.4	37.0	245.0	122.5	55.7
	1/32	89.6	44.8	26.1	154.7	77.0	35.1
	1/16	60.2	30.1	17.5			
	3/32	46.8	23.4	13.6			
	1/8						
1/4	1/64	120.4	60.2	35.1	225.0	122.7	51.3
	1/32	84.7	42.3	24.7			
	1/16	57.1	28.5	16.6			
	1/32						
3/8	1/64						
	1/32						
	1/16						

TOOL CONTOUR AND ANGLES, R.H. SHOWN



TOOL CUTTING ANGLES	CAST IRON: SOFT	CAST IRON: MED.	CAST IRON: HARD	STEEL: SOFT	STEEL: MED.	STEEL: HARD
BACKSLOPE A	11°	11°	6°	12½°	11°	6¾°
LIP ANGLE B	71	71	77	69	71	76
SIDE SLOPE C	7½°	7½°	4°	8¾°	7½°	4½°
SCLEROSCOPE HARDNESS FOR MATERIAL						

WORK FOR WHICH THIS TOOL IS ADAPTED

1- Roughing Cuts
2. Finishing Cuts when Small Feeds are Used.
3. Feed Toward the Left with R.H. Tool and Toward the Right with L.H. Tool—Speeds are Based on Tool Axis being Inclined 60°-45° to Line of Feed.
4 Not Adapted for Finishing Work which Requires Sharp Angles in Contours.
5. When Tool is Cooled by a Large Stream of Water, Increase Speeds by 15 Per Cent. 6 For Special Sharp Pointed Tool Contours Use 90 Per Cent Tabulated Speeds. 7 Angle (A') is the same as Angle (A) on Straight Shank Tools.

FIGURE 59. FEEDS AND SPEEDS IN BOTH CAST IRON AND STEEL FOR 5/16-INCH SPECIAL TOOL HOLDER ROUGHING BIT

468 *2* Construction Orders.

a On receipt of the requisition duly approved, a Construction Order shall be made out in triplicate by the Cost Department.

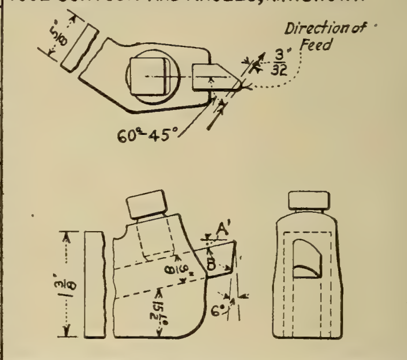
b All Construction Orders shall have an S-Order

number. S-Orders shall bear the prefix "S" and be numbered serially in the order in which they are issued, orders for new construction starting at 1 and extending to 500 and then repeating; orders for tools, jigs, fixtures and dies starting at 5000 and extending to 6000 and then repeating.

c One copy of the order shall be retained in the Cost Department, with the requisition attached.

DEPTH OF CUT IN INCHES	FEED IN INCHES	CAST IRON			STEEL		
		SOFT A'N'L'D & HEAVY SECTIONS	MED. AVERAGE RUN OF CASTINGS	HARD SEMI-CHILLED CASTINGS	SOFT .10-.15 CARB. STEEL	MED. A'N'L'D CAST STEEL .45 CARB.	HARD TIRE & SIMILAR HARD STEELS
1/16	1/64				375.2	187.6	85.4
	1/32				245.0	122.5	55.7
	1/16				160.3	80.5	36.4
3/32	1/64	149.8	74.9	43.6	319.0	159.6	72.8
	1/32	110.6	55.2	3.22	209.3	104.3	47.5
	1/16	77.0	38.4	22.4	136.5	68.3	31.0
	3/32	60.9	30.5	17.8	106.4	53.3	24.2
1/8	1/64	138.6	69.3	40.3	287.0	143.5	65.1
	1/32	102.2	51.1	29.8	187.6	93.8	42.6
	1/16	71.4	35.5	20.7	122.5	61.3	27.8
	3/32	57.2	28.2	16.5	95.9	47.8	21.7
	1/8	47.8	23.9	14.0			
3/16	1/64	125.3	62.5	36.4	245.7	123.2	55.9
	1/32	92.4	46.1	26.8	161.0	80.5	36.5
	1/16	64.2	31.1	18.7	105.7	52.9	24.0
	3/32	51.1	25.5	14.9			
	1/8	43.2	21.6	12.6			
1/4	1/64	116.9	58.3	34.0	223.3	112.0	50.8
	1/32	86.1	43.0	25.1	146.3	73.5	33.2
	1/16	59.9	29.9	17.5			
	3/32	47.6	23.8	13.9			
3/8	1/64	106.4	53.2	31.0	196.0	98.0	44.5
	1/32	78.4	39.2	22.8			
	1/16	54.6	27.3	15.8			

TOOL CONTOUR AND ANGLES, R.H. SHOWN



TOOL CUTTING ANGLES	CAST IRON			STEEL		
	SOFT	MED.	HARD	SOFT	MED.	HARD
BACKSLOPE A	11°	11°	6°	12½°	11°	6¾°
LIP ANGLE B	71°	71°	77°	69	71	76
SIDE SLOPE C	7½°	7½°	4°	8¾°	7½°	4½°
SCLEROSCOPE HARDNESS FOR MATERIAL						

WORK FOR WHICH THIS TOOL IS ADAPTED

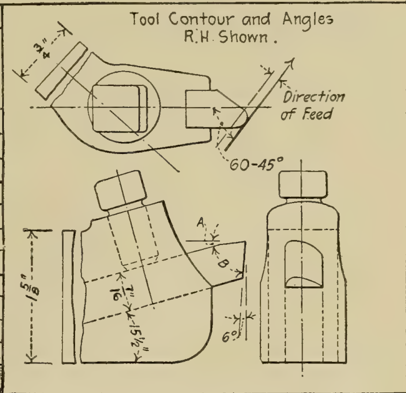
1. Roughing Cuts.
2. Finishing Cuts when Small Feeds are Used.
3. Feed Toward the Left with R.H. Tool and Toward the Right with L.H. Tool—Speeds are based on Tool Axis being Inclined 60°-45 to Line of Feed.
4. Not Adapted for Finishing Work which Requires Sharp Angles in Contours.
5. When Tools is Cooled by a Large Stream of Water, Increase Speeds by 15 Per Cent. 6. For Special Sharp Pointed Tool Contours Use 90 Per Cent Tabulated Speeds. 7. Angle (A') is the same as Angle. (A) On Straight Shank Tools.

FIGURE 60. FEEDS AND SPEEDS IN BOTH CAST IRON AND STEEL FOR 3/8-INCH SPECIAL TOOL HOLDER ROUGHING BIT

d On orders for new construction work the two other copies shall be forwarded to the supervisor of maintenance. He shall file one copy as a follow-up and send the other copy to the foreman who is to do the work if all the work is to be done in one department.

When the work is completed, the foreman shall return his copy to the supervisor of maintenance, who shall inspect the work and forward the order to the Cost Department marked "Finished." The supervisor of maintenance shall retain his copy as a permanent record of the work

DEPTH OF CUT IN INCHES	FEED IN INCHES	CAST IRON: SOFT AN'L'D & HEAVY SECTIONS	CAST IRON: MED. AVERAGE RUN OF CASTINGS	CAST IRON: HARD SEMI-CHILLED CASTINGS	STEELS: SOFT .10-.15 CARBON STEELS	STEELS: MED. AN'L'D CAST STEEL .45 CARBON	STEELS: HARD TIRE & SIMILAR HARD STEELS
1/16	1/64						
	1/32						
	1/16						
3/32	1/64	152.6	70.0	44.5	325.5	163.1	74.2
	1/32	115.5	57.7	33.6	211.4	109.2	49.6
	1/16	82.6	41.2	24.0	146.3	73.5	33.3
	3/32	66.5	33.2	18.9	115.5	57.9	26.0
1/8	1/64	140.0	69.8	40.7	289.1	144.9	65.7
	1/32	75.6	37.7	21.9	193.9	97.3	44.0
	1/16	60.9	30.4	17.7	130.2	65.0	29.5
	3/32	52.0	26.0	15.1	102.9	51.4	23.3
	1/8	41.5	20.8	12.1	86.1	43.1	19.6
3/16	1/64	123.9	62.0	36.1	245.0	122.5	55.7
	1/32	93.8	46.9	27.3	164.5	82.6	37.3
	1/16	66.9	33.5	19.5	109.9	55.1	25.0
	3/32	54.0	27.0	15.7	87.5	43.6	19.8
	1/8	46.2	23.1	13.5			
	3/16	37.0	18.4	10.7			
1/4	1/64	114.8	57.3	33.4	219.1	109.9	49.8
	1/32	86.8	43.3	25.2	147.0	73.5	33.4
	1/16	61.8	30.9	18.0	98.7	49.3	22.4
	3/32	49.8	24.9	14.5			
	1/8	42.7	21.3	12.4			
3/8	1/64	102.9	51.4	30.0	188.3	94.5	42.9
	1/32	77.7	38.9	22.7	126.7	63.2	28.7
	1/16	55.5	27.5	16.1			
	3/32	44.8	22.4	13.0			
	3/8						



TOOL CUTTING ANGLES	CAST IRON: SOFT	CAST IRON: MED.	CAST IRON: HARD	STEELS: SOFT	STEELS: MED.	STEELS: HARD
BACK SLOPE A	11°	11°	6°	12½°	11°	6¾°
LIP ANGLE B	71	71	77	69	71	76
SIDE SLOPE C	7½°	7½°	4°	8¾°	7½°	4½°
SCLEROSCOPE HARDNESS FOR MATERIAL						

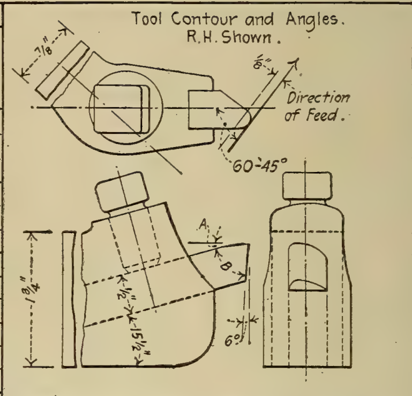
WORK FOR WHICH THIS TOOL IS ADAPTED.
1-Roughing Cuts.
2-Finishing Cuts when small Feeds are used.
3-Feed toward the Left with R.H. Tool and toward the Right with L.H. Tool-Speeds are based on Tool Axis being inclined 60°-45° to Line of Feed.
4-Not adapted for Finishing Work which requires sharp Angles in Contours.
5-When Tool is cooled by a Large Stream of Speeds, increase Speeds by 15%.
6-For Special Sharp Pointed Tool Contours use 90% Tabulated Speeds
7-Angle (A) is the same as Angle (A) on Straight Shank Tools

FIGURE 61. FEEDS AND SPEEDS IN BOTH CAST IRON AND STEEL FOR 7/16-INCH SPECIAL TOOL HOLDER ROUGHING BIT

e On orders for new tools, jigs, fixtures and dies the two copies shall be forwarded to the supervisor of production. If he determines that it is work to be handled by the Maintenance Machine Shop, he shall send both copies to the supervisor of maintenance and he shall proceed as under paragraph *d*. If the work is to be

done in a Production Department, one copy shall be given to the proper foreman, and the other copy filed in the Control Department as a follow-up on the job. When the job is completed the foreman shall return his copy of the order to the Control Department, where note shall be made of the completion of the job and forwarded to the Cost Department. The Control Department shall file its copy permanently as a record.

DEPTH OF CUT IN INCHES	FEED IN INCHES	CAST IRON SOFT AN'L'D & HEAVY SECTIONS	CAST IRON MED. AVERAGE RUN OF CASTINGS	CAST IRON HARD SEMI-CHILLED CASTINGS	STEELS SOFT .10-.15 CARBON STEELS	STEELS MED. AN'L'D CAST STEEL .45 CARBON	STEELS HARD TIRE & SIMILAR HARD STEELS
3/32	1/32	120.4	60.2	35.1	227.5	114.1	51.7
	1/16	85.4	42.7	24.9	155.4	77.7	35.2
	1/8	61.3	30.7	17.9			
1/8	1/32	109.9	55.0	32.0	200.2	100.1	45.5
	1/16	78.4	39.0	22.7	136.5	68.4	31.0
	1/8	65.1	32.5	18.9	93.1	46.6	21.2
3/16	1/64	124.6	62.2	36.3	246.4	123.2	56.0
	1/32	95.9	47.8	27.9	168.0	84.0	38.2
	1/16	70.0	35.0	20.4	114.8	57.4	26.1
	3/32	63.7	28.3	16.5	91.0	45.6	20.7
	1/8	48.8	24.4	14.2	78.4	39.1	17.7
	1/16	39.4	19.7	11.5			
1/4	1/64	114.1	56.9	33.1	218.4	109.2	49.6
	1/32	87.5	43.8	25.5	149.1	74.2	33.8
	1/16	63.6	31.8	18.5	101.5	50.8	23.1
	3/32	51.8	25.9	15.1	81.2	40.4	18.4
	1/8	44.7	22.3	13.0			
	3/16	36.1	18.0	10.5			
3/8	1/64	100.8	50.5	29.4	185.5	92.4	42.0
	1/32	77.7	38.9	22.6	126.7	63.2	28.7
	1/16	56.4	28.2	16.4	86.1	43.1	19.6
	3/32	45.9	23.0	13.4			
	1/8	39.6	19.8	11.5			
1/2	1/64	93.1	46.4	27.0	165.9	82.6	37.6
	1/32	71.4	35.7	20.8	113.4	56.5	25.6
	1/16	51.9	25.9	15.1			
	3/32	42.3	21.2	12.3			
	1/8	36.5	18.2	10.4			



TOOL CUTTING ANGLES	CAST IRON SOFT	CAST IRON MED.	CAST IRON HARD	STEELS SOFT	STEELS MED.	STEELS HARD
BACK SLOPE A	11°	11°	6°	12½°	11°	6¾°
LIP ANGLE B	71	71	77	69	71	76
SIDE SLOPE C	7½°	7½°	4°	8¾°	7½°	4½°
SCLEROSCOPE HARDNESS FOR MATERIAL						

WORK FOR WHICH THIS TOOL IS ADAPTED.

1-Roughing Cuts.
2-Finishing Cuts when small Feeds are used.
3-Feed toward the Left with R.H. Tool and toward the Right with L.H. Tool-Speeds are based on Tool Axis being inclined 60°-45° to Line of Feed.
4-Not adapted for Finishing Work which requires sharp Angles in Contours.
5-When Tool is cooled by a Large Stream of Speeds, Increase Speeds by 15%.
6-For Special Sharp Pointed Tool Contours use 90% Tabulated Speeds
7-Angle (A') is the same as Angle (A) on Straight Shank Tools.

FIGURE 62. FEEDS AND SPEEDS IN BOTH CAST IRON AND STEEL FOR ½-INCH SPECIAL TOOL HOLDER ROUGHING BIT

469 *3* Construction Sub-Orders.

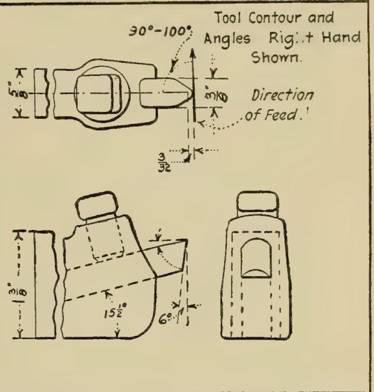
a Where more than one department is to do work on a Construction Order, Construction Sub-Orders shall be made out showing the department to which issued, the S-Order number as shown on the Construction

Order, date issued, date wanted, where to deliver work when finished, blueprint numbers, description of work to be done, and signature of person issuing.

b On orders for new construction work, the supervisor of maintenance shall retain both copies of the Con-

FEEDS AND SPEEDS TO USE WITH TOOL SPECIFIED BELOW

DEPTH OF CUT IN INCHES	FEED IN INCHES	CAST IRON			STEEL		
		SOFT A'N'L'D & HEAVY SECTIONS	MED. AVERAGE RUN OF CASTING	HARD SEMI-CHILLED CASTINGS	SOFT .10-15 CARBON STEEL	MED. A'N'L'D CAST STEEL 45 CARBON	HARD TIRE & SIMILAR HARD STEELS
1/16	1/64				348.4	174.2	79.3
	1/32				227.5	113.7	51.7
	1/16				148.8	74.7	33.8
3/32	1/64	139.1	69.5	40.4	296.4	148.2	67.6
	1/32	102.7	51.2	29.9	194.8	96.8	44.1
	1/16	71.5	35.6	20.8	126.7	63.5	28.8
	3/32	56.5	28.4	16.5	98.8	49.5	22.4
1/8	1/64	128.7	64.3	37.5	265.5	133.2	60.5
	1/32	94.9	47.4	27.6	174.2	87.1	39.6
	1/16	66.3	33.0	19.3	113.7	56.9	25.8
	3/32	53.1	26.2	15.3	89.0	44.4	20.2
	1/8	44.4	22.2	13.0			
3/16	1/64	116.3	58.1	33.8	228.1	114.4	51.9
	1/32	85.8	42.8	24.9	149.5	74.7	33.9
	1/16	59.6	29.8	17.4	98.1	49.2	22.3
	3/32	47.4	23.7	13.8			
	1/8	40.1	20.0	11.7			
1/4	1/64	108.5	54.2	31.5	207.3	104.0	47.1
	1/32	79.9	39.9	23.3	135.8	68.2	30.8
	1/16	55.6	27.8	16.2			
	3/32	44.2	22.1	12.9			
3/8	1/64	98.8	49.4	28.7	182.0	91.0	41.3
	1/32	72.8	36.4	21.2			
	1/16	50.7	25.3	14.7			



TOOL CUTTING ANGLES	CAST IRON			STEEL		
	SOFT	MED.	HARD	SOFT	MED.	HARD
BACK SLOPE A	13°	13°	7°	15°	13°	8°
LIP ANGLE B	71°	71°	77°	69°	71°	76°
SIDE SLOPE C	0	0	0	0	0	0
SCLEROSCOPE - HARDNESS FOR MATERIAL						

WORK FOR WHICH THIS TOOL IS ADAPTED

1- Roughing Cuts.
2- Finishing Cuts when Small Feeds are used.
3- Feed either toward the Right or Left. Speeds are Based on Tool Axis being Perpendicular to the Line of Feed-When Inclined 60°-45 to Line of Feed, Increase Speeds by 8%.
4- Not adapted for Finishing Work which Requires Sharp Angles in Contours.
5- When Tool is Cooled by a Large Stream of Water. Increase Speeds by 15%.
6- For Special Sharp Pointed Tool Contours, use 90% of Tabulated Speeds when Perpendicular to Line of Feed, and 98° when Inclined 60°-45° with Line of Feed.

FIGURE 63. FEEDS AND SPEEDS IN BOTH CAST IRON AND STEEL FOR ⅜-INCH TOOL HOLDER ROUGHING BIT

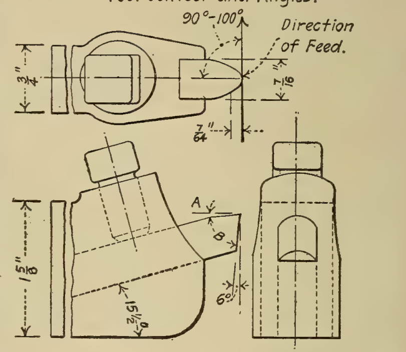
struction Order and make out a Construction Sub-Order in duplicate for each department which is to do work on the order, retaining the duplicate copy attached to the Construction Order and sending the original copy to the proper foreman.

c On orders for tools, jigs, fixtures or dies the foreman of the tool room shall receive his copy of the Construction Order from the Control Department, as usual. He shall issue a Construction Sub-Order on each department that is to do work on the order, forwarding

FEEDS AND SPEEDS TO USE WITH TOOL SPECIFIED BELOW.

DEPTH OF CUT IN INCHES	FEED IN INCHES	CAST IRON SOFT AN'L'D & HEAVY SECTIONS	CAST IRON MED. AVERAGE RUN OF CASTINGS	CAST IRON HARD SEMI-CHILLED CASTINGS	STEEL SOFT .10-.15 CARBON STEEL	STEEL MED. AN'L'D CAST STEEL .45 CARBON	STEEL HARD TIRE & SIMILAR HARD STEELS
1/16	1/64						
	1/32						
	1/16						
3/32	1/64	141.7	65.0	41.3	302.2	151.4	68.9
	1/32	107.2	53.6	31.2	196.3	101.4	46.0
	1/16	76.7	38.2	22.3	135.8	68.2	30.9
	3/32	61.7	30.8	17.6	107.2	53.8	24.1
1/8	1/64	130.0	64.8	37.8	268.4	134.5	61.0
	1/32	98.1	49.0	28.6	180.0	90.3	40.8
	1/16	70.2	35.0	20.4	120.9	60.3	27.4
	3/32	56.5	28.2	16.5	95.5	47.7	21.7
	1/8	48.3	24.1	14.1	79.9	40.0	18.2
3/16	1/64	115.0	57.6	33.6	227.5	113.7	51.7
	1/32	87.1	43.6	25.4	152.7	76.7	34.7
	1/16	62.2	31.1	18.1	102.0	51.2	23.2
	3/32	50.1	25.1	14.6	81.2	40.5	18.3
	1/8	42.9	21.4	12.5			
	3/16	34.3	17.1	10.0			
1/4	1/64	106.6	53.2	31.0	203.4	102.0	46.2
	1/32	80.6	40.2	23.4	136.5	68.2	31.0
	1/16	57.4	28.7	16.7	91.6	45.8	20.8
	3/32	46.3	23.2	13.5			
	1/8	39.7	19.8	11.5			
3/8	1/64	95.5	47.7	27.8	174.8	87.7	39.8
	1/32	72.1	36.1	21.1	117.6	58.7	26.7
	1/16	51.5	25.7	15.0			
	3/32	41.6	20.8	12.1			
	1/8						

Tool Contour and Angles.



TOOL CUTTING ANGLES	CAST IRON SOFT	CAST IRON MED.	CAST IRON HARD	STEEL SOFT	STEEL MED.	STEEL HARD
BACK SLOPE A	13°	13°	7°	15°	13°	8°
LIP ANGLE B	71°	71°	77°	69°	71°	76°
SIDE SLOPE C	0	0	0	0	0	0
SCLEROSCOPE HARDNESS FOR MATERIAL.						

WORK FOR WHICH THIS TOOL IS ADAPTED.

1- Roughing Cuts.
2- Finishing Cuts when small Feeds are used.
3- Feed either toward the Right or Left. Speeds are based on Tool Axis being Perpendicular to the Line of Feed—When inclined 60°-45° to Line of Feed; increase Speeds by 8 %.
4- Not adapted for Finishing Work which requires sharp Angles in Contour.
5- When Tool is Cooled by a large Stream of Water, increase Speeds by 15%.
6- For Special Sharp Pointed Tool Contours, use 90% of Tabulated Speeds when Perpendicular to Line of Feed, and 98% when inclined 60°-45° with Line of Feed.

FIGURE 64. FEEDS AND SPEEDS IN BOTH CAST IRON AND STEEL FOR 7/16-INCH TOOL HOLDER ROUGHING BIT

the original copy and retaining the duplicate attached to the Construction Order.

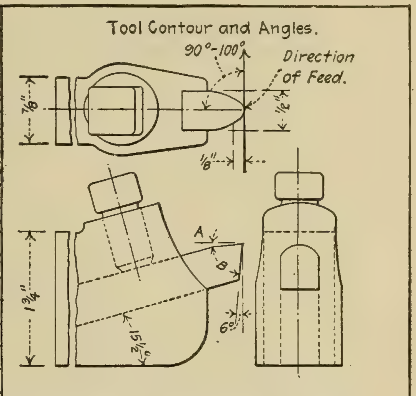
d Upon completion of the work, the original copies shall be returned to the supervisor of maintenance or the foreman of tool room, and note made on his copy of the date the Sub-Order was finished.

e When the Construction Order is finished, it shall be returned, with Sub-Orders attached, to the Cost Department, as outlined in paragraph 2*d*.

470 *4* Requisitions for Material.

Requisitions for material to be used on Construction Orders or Sub-Orders shall bear the S-Order number that the work is being done on. Labor, material and overhead shall be charged in on all Construction Orders.

DEPTH OF CUT IN INCHES	FEED IN INCHES	CAST IRON SOFT AN'L'D & HEAVY SECTIONS	CAST IRON MED. AVERAGE RUN OF CASTINGS	CAST IRON HARD SEMI-CHILLED CASTINGS	STEEL SOFT .10-.15 CARBON STEEL	STEEL MED. AN'L'D CAST STEEL 45 CARBON	STEEL HARD TIRE & SIMILAR HARD STEELS
3/32	1/32	111.8	559	32.6	211.2	105.9	48.0
	1/16	1443	39.6	23.1	144.3	72.1	32.7
	1/8	1570	28.5	166			
1/8	1/32	102.0	51.0	29.7	185.9	92.9	42.3
	1/16	72.8	36.2	21.1	126.7	63.5	28.8
	1/8	52.1	26.0	15.2	86.4	43.3	19.6
3/16	1/64	115.7	57.7	33.7	228.8	114.4	52.0
	1/32	890	44.4	25.9	156.0	78.0	35.4
	1/16	65.0	325	18.9	106.6	53.3	24.2
	3/32	59.1	26.3	15.3	845	42.3	19.3
	1/8	45.5	22.6	132	72.8	36.3	16.5
	3/16	36.6	18.3	107			
1/4	1/64	1059	52.8	308	302.8	101.4	46.0
	1/32	812	40.6	33.7	138.4	68.9	31.4
	1/16	590	29.5	17.2	94.2	47.1	21.4
	3/32	48.1	24.1	14.0	75.4	37.5	171
	1/8	41.5	20.7	120			
	3/16	33.5	16.7	9.8			
3/8	1/64	93.6	46.9	273	172.2	85.8	39.0
	1/32	72.1	36.1	210	117.6	58.6	26.6
	1/16	52.3	26.1	15.2	79.9	40.0	18.2
	3/32	42.7	21.3	124			
	1/8	36.8	18.3	10.7			
1/2	1/64	86.4	43.1	25.1	154.0	76.7	349
	1/32	66.3	33.2	19.3	105.8	52.5	23.8
	1/16	48.2	24.1	14.1			
	3/32	39.3	196	11.5			
	1/8	339.	169	9.6			



TOOL CUTTING ANGLES	CAST IRON SOFT	CAST IRON MED.	CAST IRON HARD	STEEL SOFT	STEEL MED.	STEEL HARD
BACK SLOPE A	13°	13°	7°	15°	13°	8°
LIP ANGLE B	71°	71°	77°	69°	71°	76°
SIDE SLOPE C	0	0	0	0	0	0
SCLEROSCOPE HARDNESS FOR MATERIAL.						

WORK FOR WHICH THIS TOOL IS ADAPTED.

1- *Roughing Cuts.*
2- *Finishing Cuts when small Feeds are used*
3- *Feed either toward the Right or Left. Speeds are based on Tool Axis being Perpendicular to the Line of Feed—When inclined 60°-45° to Line of Feed, increase Speeds by 8%.*
4- *Not adapted for Finishing Work which requires sharp Angles in Contours*
5- *When Tool is Cooled by a large Stream of Water, increase Speeds by 15%*
6- *For Special Sharp Pointed Tool Contours, use 90% of Tabulated Speeds when Perpendicular to Line of Feed, and 98% when inclined 60°-45° with Line of Feed.*

FIGURE 65. FEEDS AND SPEEDS IN BOTH CAST IRON AND STEEL FOR ½-INCH TOOL HOLDER ROUGHING BIT

471 MOVING OF MACHINERY AND EQUIPMENT.

Purpose of Method: To provide a means of ordering the moving of machinery or equipment, and of giving the Cost Department a notice so that they may change their records

if the movement is from one department to another, or if sold or scrapped.

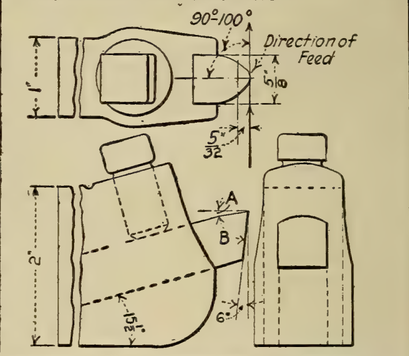
472 METHOD HANDLED BY—

1 Supervisor of production.
2 Supervisor of maintenance.
3 Foreman of carpenters and millwrights.
4 Cost Department.

FEEDS AND SPEEDS TO USE WITH TOOL SPECIFIED BELOW

DEPTH OF CUT IN INCHES	FEED IN INCHES	CAST IRON SOFT A'N'L'D & HEAVY SECTIONS	CAST IRON MED. AVERAGE RUN OF CASTINGS	CAST IRON HARD SEMI-CHILLED CASTINGS	STEEL SOFT .10-.15 CARBON STEEL	STEEL MED. A'N'L'D CAST STEEL .45 CARB.	STEEL HARD TIRE & SIMILAR HARD STEELS
3/32	1/32	117.0	58.6	34.2	221.0	110.5	50.1
	1/16	86.4	43.2	25.1	152.7	76.7	34.7
	1/8	61.4	30.7	17.9			
1/8	1/32	105.3	52.8	30.8	192.4	96.2	43.7
	1/16	78.0	38.8	22.6	133.2	66.3	30.2
	1/8	55.3	27.6	16.1	92.3	46.1	20.9
3/16	1/64	117.6	58.7	34.2	232.0	116.3	52.7
	1/32	91.6	45.8	26.7	160.5	80.6	36.5
	1/16	67.6	33.6	19.6	111.1	55.6	25.2
	3/32	55.3	27.6	16.1	89.7	44.7	20.3
	1/8	47.9	23.9	13.9	77.3	38.5	17.4
	3/16	39.0	19.5	11.3	62.0	31.0	14.1
1/4	1/64	106.6	53.3	31.1	204.1	102.0	46.4
	1/32	83.2	41.6	24.2	141.7	70.8	32.1
	1/16	61.2	30.6	17.8	98.1	48.9	22.2
	3/32	50.3	25.1	14.7	78.6	39.3	17.8
	1/8	43.6	21.7	12.7	67.6	33.8	15.4
	3/16	35.4	18.0	10.3			
3/8	1/64	93.6	46.8	27.3	172.2	86.4	39.1
	1/32	72.8	36.5	21.3	118.9	59.7	27.1
	1/16	53.7	26.9	15.6	82.5	41.3	18.7
	3/32	44.2	22.1	12.8	66.3	33.2	15.1
	1/8	38.2	19.1	11.1			
1/2	1/64	85.8	42.8	24.9	152.1	76.0	34.5
	1/32	66.9	33.4	19.5	105.3	52.5	23.9
	1/16	49.1	24.5	14.3	72.8	36.3	16.5
	3/32	40.3	20.2	11.7			
	1/8	34.9	17.4	10.2			

TOOL CONTOUR AND ANGLES



TOOL CUTTING ANGLES	CAST IRON HARD	CAST IRON MED.	CAST IRON SOFT	STEEL HARD	STEEL MED.	STEEL SOFT
BACK SLOPE A	13°	13°	7°	15°	13°	8°
LIP ANGLE B	71°	71°	77°	69°	71°	76°
SLIDE SLOPE C	0	0	0	0	0	0
SCLEROSCOPE HARDNESS FOR MATERIAL						

WORK FOR WHICH THIS TOOL IS ADAPTED

1. Roughing Cuts.
2. Finishing Cuts when Small Feeds are Used
3. Feed either toward the Right or Left Speeds are based on Tool Axis being Perpendicular to the Line of Feed—when Inclined 60°-45° to Line of Feed, Increase Speeds by 8 Per Cent.
4. Not Adapted for Finishing Work which Requires Sharp Angles in Contours.
5. When Tool is Cooled by a Large Stream of Water, Increase Speeds by 15 Per Cent.
6. For Special Sharp Pointed Tool Contours Use 90 Per Cent of Tabulated Speeds. When Perpendicular to Line of Feed and 98 Per Cent when Inclined 60°-45° with Line of Feed.

FIGURE 66. FEEDS AND SPEEDS IN BOTH CAST IRON AND STEEL FOR 5/8-INCH TOOL HOLDER ROUGHING BIT

473 PROCEDURE IN HANDLING:

1 Whenever any machinery or equipment is to be moved, whether within a department or from one depart-

ment to another or to the yard to be sold or scrapped, a Maintenance Order shall be made out in three copies.

2 The Maintenance Order shall show the department issuing, account to charge, date issued, date wanted, machine number, location of machine, and, under "Nature of Work," the name and description of the machine and the department where it is to be moved and set up.

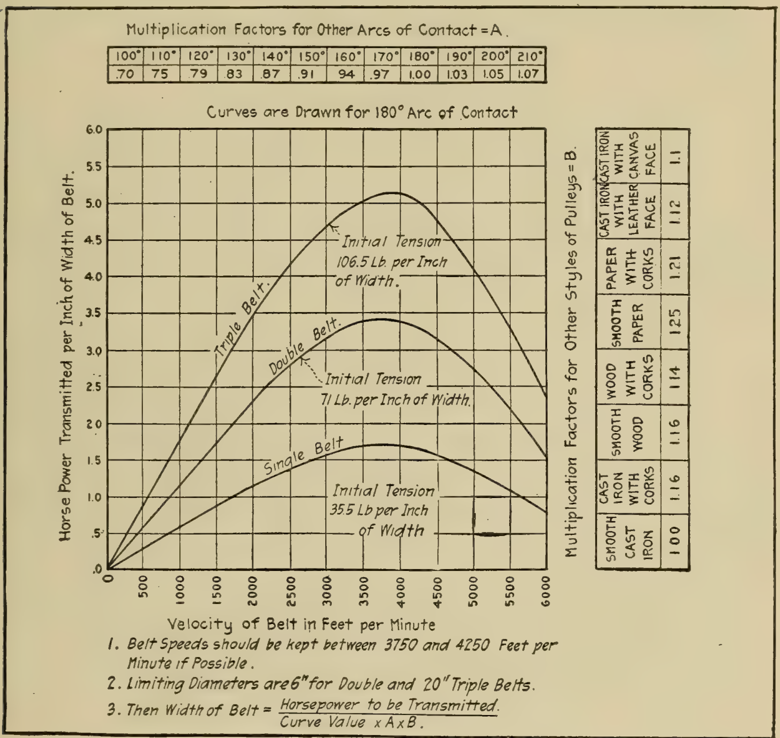


FIGURE 67. HORSEPOWER TRANSMITTED BY STANDARD LEATHER BELTS

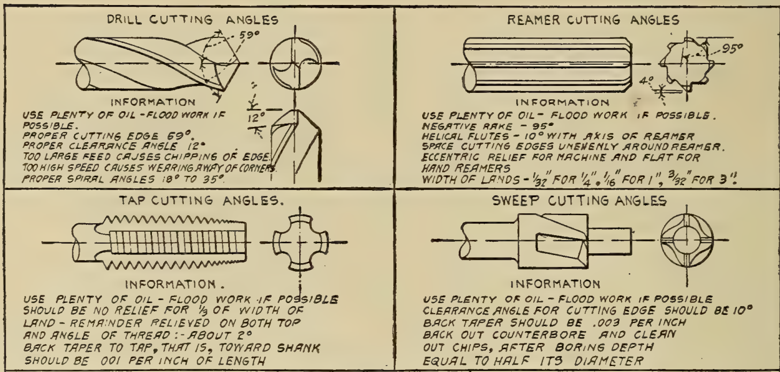
3 If the machinery or equipment is used by one of the production departments, the order shall be made out and approved by the supervisor of production, who shall retain one copy in his book and send the other two copies to the supervisor of maintenance.

4 If the machinery or equipment is used by one of the maintenance departments, the order shall be made out by the supervisor of maintenance, who shall retain one copy in his book and handle the other two copies in a similar

manner to any he may receive from the supervisor of production (see paragraph 3 above).

5 One copy shall be filed in the Maintenance Office according to serial number and the other copy given to the foreman in charge of carpenters and millwrights.

6 When the machinery or equipment has been moved and set up as ordered, the foreman in charge of carpenters and millwrights shall fill in the date finished and return his copy to the Maintenance Office, marked "Finished."



SPEEDS OF CUT IN FEET PER MINUTE - CARBON & HIGH SPEED TOOLS									FEEDS IN INCHES PER REV DRILLS & REAMERS					
MATERIAL MACHINED	DRILLS C.S.	DRILLS H.S.	REAMERS C.S.	REAMERS H.S.	TAPS C.S.	TAPS H.S.	SWEEPS C.S.	SWEEPS H.S.	DIA.	DRILL	REAMER	DIA	DRILL	REAMER
CAST IRON - SOFT WELL ANNEALED	55	110	35	70	40	80	20	40	1/16	0001	0002	7/8	0013	0.034
CAST IRON - MED. AVERAGE RUN OF CASTINGS	35	70	20	40	20	40	15	30	1/8	0003	0006	1	0014	0.042
CAST IRON - HARD SEMI - CHILLED	20	40	10	25	5	10	10	20	3/16	0004	0.008	1 1/4	0016	0042
MALLEABLE IRON SMALL CASTINGS	40	80	25	50	15	30	15	30	1/4	0.006	0012	1 1/2	0.016	0048
STEEL - SOFT MILD -.10-.15 CARBON.	50	100	30	60	15	30	20	40	5/16	0.007	0017	1 3/4	0016	0048
STEEL - MED. FORGINGS - TOOL STEEL	25	50	15	30	10	20	20	40	3/8	0008	0020	2	0016	0048
STEEL - HARD TIRE STEEL	20	40	10	25	5	10	10	20	7/16	0009	0023	2 1/4	0018	0054
CAST STEEL ANNEALED	25	50	15	30	10	20	15	30	1/2	0010	0030	2 1/2	0.018	0.054
CAST STEEL UNANNEALED	20	40	10	25	10	15	10	20	5/8	0011	0033	2 3/4	0018	0054
BRONZE BRASS	75	150	40	90	45	90	40	80	3/4	0012	0036	3	0.018	0054

FIGURE 68. SPEEDS AND FEEDS FOR DRILLS, REAMERS, TAPS AND SWEEPS

7 The supervisor of maintenance shall then remove the copy from the unfilled-orders file and file it in the completed-orders file. The foreman's copy shall be forwarded to the Cost Department, so that they may change their records if necessary.

8 No machinery or equipment shall be moved except under the direction of the foreman of carpenters and

millwrights, and only on receipt of a Maintenance Order, duly approved.

9 The brass number shall always remain on the machine, no matter where it is moved to, and in no case shall it be removed until the machine has been sold as second-hand machinery or scrapped.

10 Any questions relative to the moving of machinery

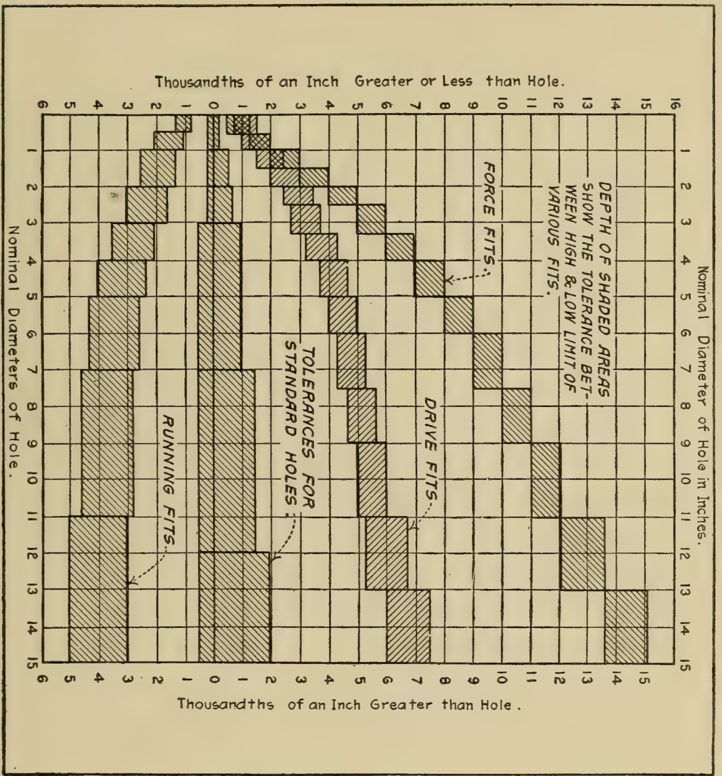


FIGURE 69. ALLOWANCES FOR VARIOUS KINDS OF FITS IN DIAMETERS FROM 1 TO 15 INCHES, INCLUSIVE

or equipment upon which the supervisor of production and the supervisor of maintenance cannot agree, shall be referred to the assistant general manager for a decision.

474 With product, material and equipment elements under control, the next factor to consider is that of labor, after which we can take up the matter of coördinating these four elements in controlling production.

Chapter XVI

LABOR CONTROL

475 As stated in a previous chapter, what we should know in order to give us a proper control of labor is, as to each worker—

A Was the worker in?
B How many hours did he work?
C What is his rate per hour? Or the piece rates?
D What are his earnings for the day?
E What different jobs did he work on?
F How much time did he work on each job?
G How many good pieces did he produce on each job?
H How many bad pieces on each job?
I What was the standard hourly production on each job?
J What was his efficiency ratio of standard to actual on each job? For the day? Week? Month?
K What is the cost of each? What should job have cost?
L Does the cost and time on all jobs correspond to the time spent in the plant and the wages paid?

476 To get the above information, it means that we must arrange for an efficient means of keeping time of equipment and men; secure information as to good and bad pieces produced; provide a means for showing standard hourly production against which we can measure attainments, and record cost of time taken for work done.

477 The mechanism used consists of the following:

Time cards, on which to record time and production.
Rejection cards, on which to record defective work.

Allowance cards, on which to allow worker for delays beyond his control.

Identification and Move cards, on which to show routings and identify and move work.

Dispatch boards. as the clearing house for the above records.

478 Dispatch clerks, through the medium of these dispatch boards, perform all the clerical work in connection with labor control, many times taking over clerical work performed by foremen and even workmen, thus releasing them for more important work in connection with their regular duties.

The duties of these dispatch clerks are—

A Timekeeping.
B Distribution of work.
C Recording work finished.
D Recording arrival of material.
E Recording idle equipment.
F Arranging for proper sequence of work.
G Reporting on breakdowns and delays.
H Recording jobs being worked on.
I Seeing that there are jobs ahead, with everything in readiness for them—material, tools, drawings.
J Recording rejections and spoiled work.

479 Dispatch boards are provided with one spring clip for each man, machine, or working space, on which are time tickets covering jobs being worked on and jobs ahead, the ticket covering the job being worked on to be at the top, and those covering jobs ahead being behind it and arranged in order of their sequence. See Figures 9 and 10, Chapter XI, for illustration of a dispatch board.

480 If desired, two spring clips can be used for each man, machine or working space, the top clip for job being worked on, and the lower clip for jobs ahead.

481 It might be well to say that dispatch boards are located in convenient places in the shop, in which the workmen report when starting work, also when finishing same. It is often convenient to have a single-clip board at the ma-

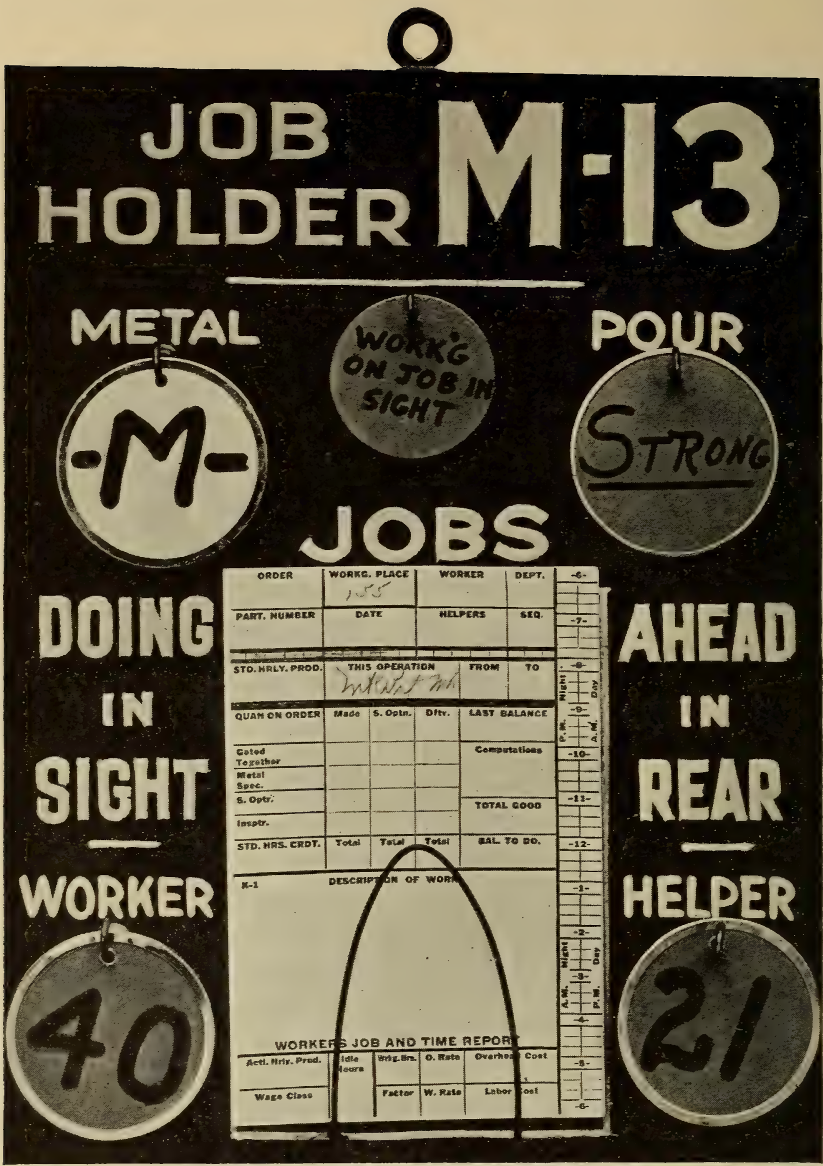


FIGURE 70. JOB HOLDER FOR FOUNDRY WORKING PLACE

chine to hold duplicate cards of jobs being worked on, along with notification of next job. (See Figure 70.) In this way a foreman or representative of the Control Department can keep posted, while in the shops, as to jobs being worked on and jobs ahead.

482 For forms of time cards, see Figures 71, 72 and 73. With Figure 71, the principle is that of using an ordinary dollar clock with the decimal dial replacing regular dial, and entering time started and quit on service cards from this clock, with indelible pencil.

483 In Figures 72 and 73 the principle is that of using a conductor's punch for punching started and quit times. Figures 71 and 72 are used in the ordinary methods of re-

MACHINE SHOP SERVICE CARD			
ORDER NO.	FOR UNIT	DATE	
DRAWING NO.	PART	UNITS OF WORK	
JOB NO.		PIECE WORK	
	GROUP NO. SHEET ITEM	DAY WORK	

PRODUCTION			TIME AND COST			
ITEM	PIECES	UNITS	MEN	TIME	RATE	COST
ON ORDER			LEADER	QUIT		
PREVIOUSLY FINISHED				STARTED		
FINISHED THIS DATE			HELPERS	ELAPSED		
TOTAL TO DATE				ALLOW		
BALANCE				NET ACTUAL		

STANDARD	THIS OPERATION	NEXT OPERATION	MOVED
HOURLY PRODUCTION	NAME	NAME	DATE
ACTUAL HOURLY	MACHINE	MACHINE	
PRODUCTION.	DEPT.	DEPT.	BY

Figure 71. Standard Form of Time Card Intended for Pencil Entry

cording and tabulating, while Figure 73 is used in connection with electrical machines for recording and tabulation.

484 Colors can be used to advantage in using time cards, as follows:

Direct Labor—Day work.	Salmon.
Direct Labor—Piece work.	Yellow.
Direct Labor Loaned.	Same cards, marked "Transfer to."
Indirect Labor.	Green.
Indirect Labor Loaned.	Same, marked "Transfer to."
Work for other Departments.	Green.
Idle Time Paid for.	Blue.
Idle Time of Equipment.	Pink.
Bonus Report.	Brown.
Absent.	Red.

485 As can be readily seen, these distinguishing colors are a form of graphic presentation, for a glance at a dispatch board will show the exact condition of the shop.

486 To give a better conception of procedure necessary

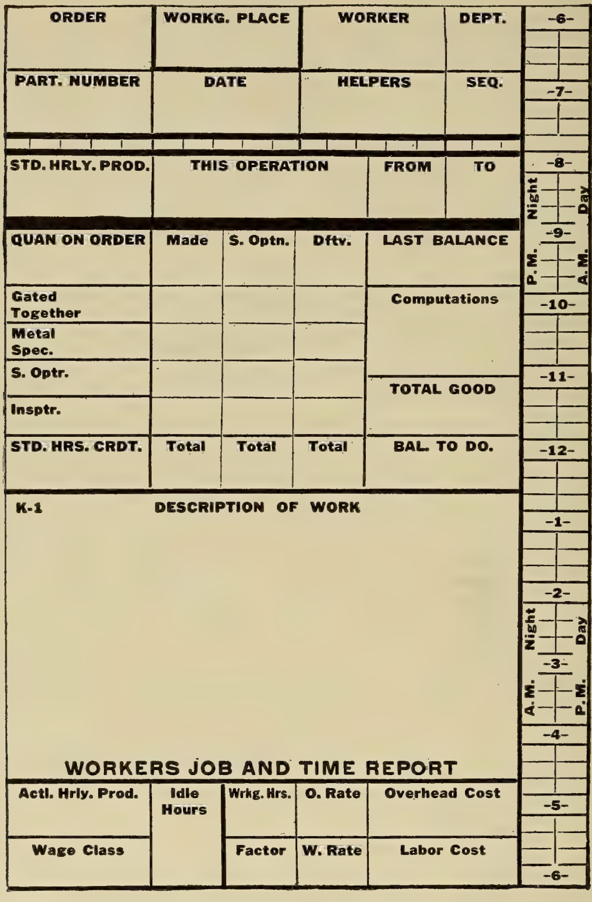

ORDER | WORKG. PLACE | WORKER | DEPT.
PART. NUMBER | DATE | HELPERS | SEQ.
STD. HRLY. PROD. | THIS OPERATION | FROM | TO
QUAN ON ORDER | Made | S. Optn. | Dftv. | LAST BALANCE
Gated Together
Metal Spec.
S. Optr.
Insptr.
Computations
TOTAL GOOD
STD. HRS. CRDT. | Total | Total | Total | BAL. TO DO.
K-1 DESCRIPTION OF WORK
WORKERS JOB AND TIME REPORT
Actl. Hrly. Prod. | Idle Hours | Wrkg. Hrs. | O. Rate | Overhead Cost
Wage Class | Factor | W. Rate | Labor Cost
-6- -7- -8- Night Day -9- P. M. A. M. -10- -11- -12- -1- -2- Night Day -3- A. M. P. M. -4- -5- -6-

Figure 72. Form of Time Card to be Used with Conductor's Punch

to labor control, the following explanations will prove helpful:

487 Direct Labor (covering Figure 73, salmon and yellow time cards) is that labor performed directly on an article used for sale, and is reported on piece-work or day-work cards, Figure 73. The spaces are numbered corresponding to the numbered paragraphs for quick reference.

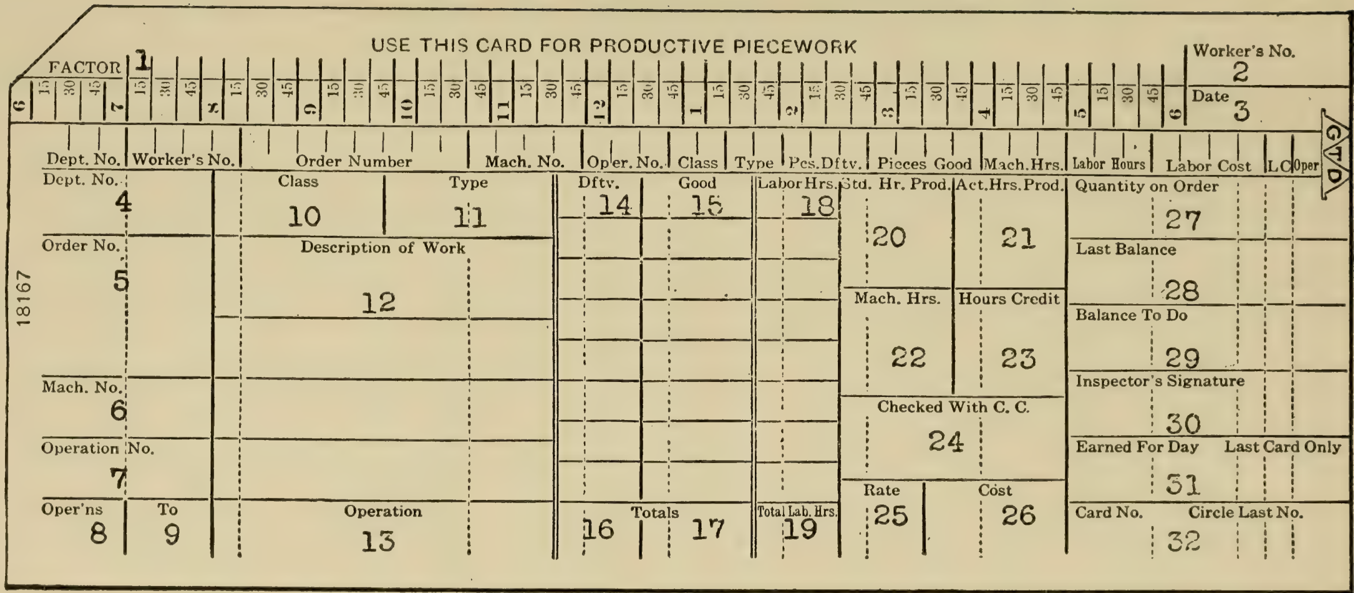


Figure 73. Form of Time Card for Mechanical Tabulation

488 The Piece-work Card.

1 *Factor.* See Special Instructions and sample.

2 *Worker's No.* Use the worker's clock card number.

3 *Date.* Use date stamp and be sure that every card leaving the dispatch booth is dated correctly.

4 *Dept. No.* Place here the number of the department where the worker is employed. (Consult code.)

5 *Order No.* Use the order number appearing on the Identification and Move card.

6 *Mach. No.* The number of the machine which a worker is operating.

7 *Operation No.* The operation number shown on the Identification and Move card, or on the Operation Code.

8 *Operations.* The total number of operations as shown by the Identification and Move card.

9 *To* ——. The next operation to which the product goes.

10 *Class.* The class of goods as shown by the product code.

11 *Type.* The type of goods as shown by the product code.

12 *Description of Work.* A description of the product.

13 *Operation.* The name of the operation being performed.

14 *Defv.* The number of pieces spoiled in each successive lot finished.

15 *Good.* The number of pieces finished good in each successive lot.

16 *Totals.* The sum of 14.

17 *Totals.* The sum of 15.

18 *Labor Hours.* See Special Instructions.

19 *Total Labor Hours.* In this space should appear the total number of labor hours represented by that card.

20 *Std. Hour Prod.* Not to be used by dispatch clerks.

21 *Act. Hour Prod.* Not to be used by dispatch clerks.

22 *Mach. Hrs.* In this space should appear the total number of machine hours represented by that card.

23 *Hours' Credit.* Not to be used by dispatch clerks.

24 Checked with C C. In this space should appear the initials or a distinguishing check mark showing that the card has been checked with the "in and out" clock card, and by whom.

25 Rate. The rate per hundred for that particular product and operation.

26 Cost. Rate (25) multiplied by total good (17).

27 Quantity on Order. The total quantity ordered, as shown by the Identification and Move card.

28 Last Balance. The balance remaining when the previous quantities finished have been subtracted from the quantity on order.

29 Balance to Do. The quantity still unfinished, obtained by subtracting the total good and defective (16 and 17) from the last balance. Note that 27 and 28 will in many cases be the same.

30 Inspector's Signature.

31 Earned for Day. Not to be used by dispatch clerks.

32 Card No., etc. Place in this space the card number, number the workers' cards consecutively and place a circle around the last card number. Starting in the morning, the first card will be one, the second two, etc. Cards for workers, if they are running more than one machine, are to have consecutive numbers also. No two cards to have the same number.

489 GANG PIECE-WORK. Where two, three or more individuals are working together on a share basis, put in tickets for each and place the order number on each. Report the number of pieces on one ticket and mark on the other: "See No. ——." The basis of division should appear on all tickets.

490 THE DAY-WORK CARD. The information required on the day-work card is exactly the same as the piece-work card, with the exception of 25—this space is not to be used by the dispatch clerk.

491 FACTORS. Three cards (Figure 74) are shown, representing ten hours' work for No. 628. The cards show that he started work on these machines at 7 A.M. At 10 A.M. Machine No. 1025 stops on account of breakdown (see red

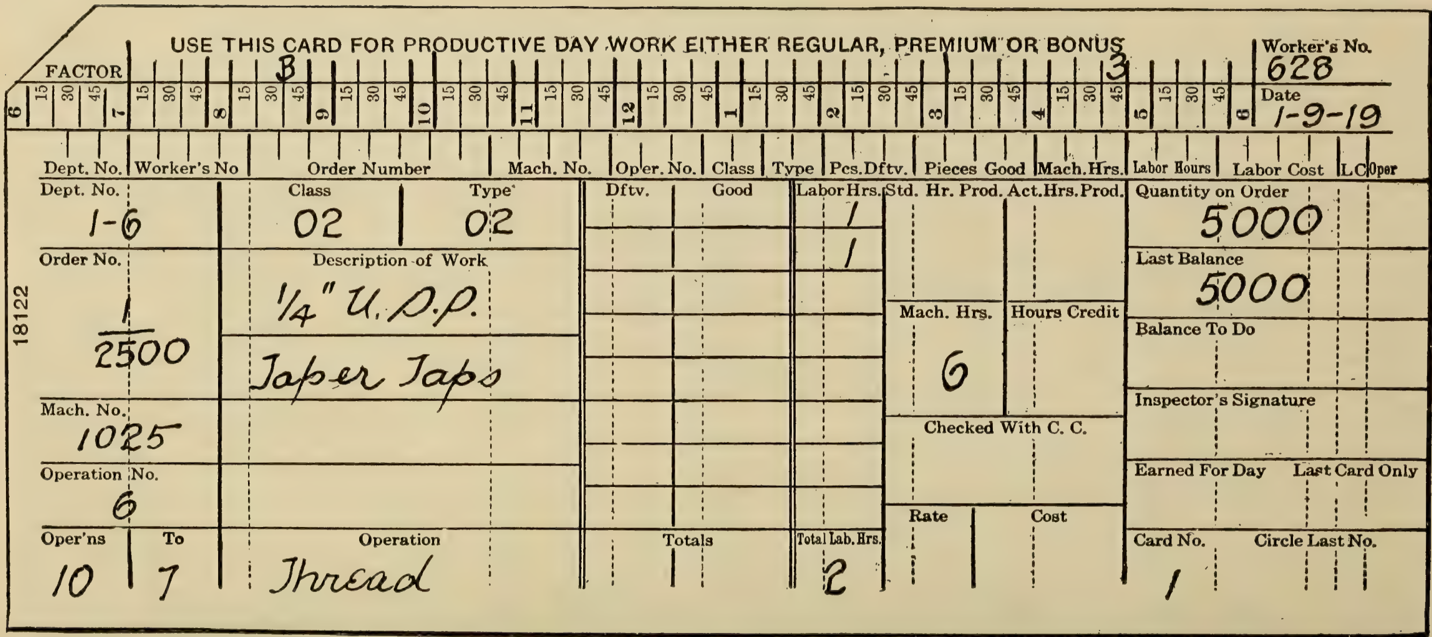
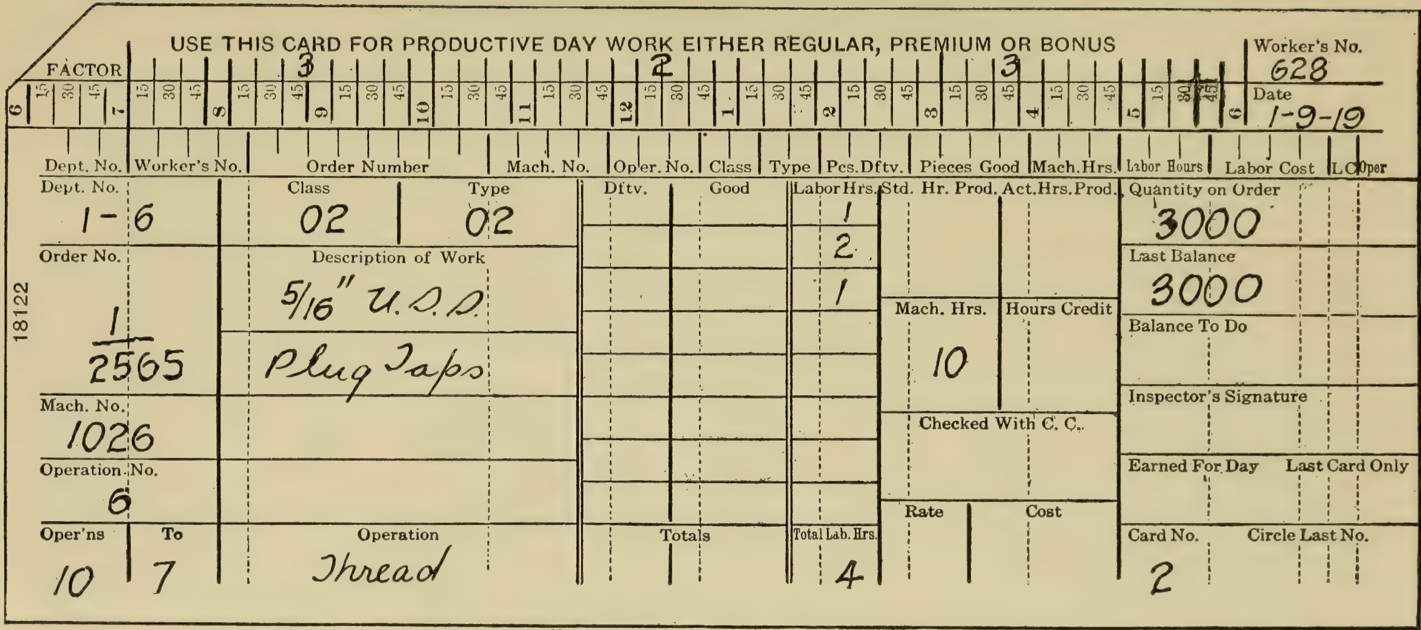

USE THIS CARD FOR PRODUCTIVE DAY WORK EITHER REGULAR, PREMIUM OR BONUS
FACTOR
6 15 30 45 7 15 30 45 8 15 30 45 9 15 30 45 10 15 30 45 11 15 30 45 12 15 30 45 1 15 30 45 2 15 30 45 3 15 30 45 4 15 30 45 5 15 30 45 6
B
3
Worker's No. 628
Date 1-9-19
Dept. No. | Worker's No | Order Number | Mach. No. | Oper. No. | Class | Type | Pcs. Dftv. | Pieces Good | Mach. Hrs. | Labor Hours | Labor Cost | LC | Oper
18122
Dept. No. 1-6
Class 02
Type 02
Order No. 1/2500
Description of Work 1/4" U.S.P. Taper Taps
Mach. No. 1025
Operation No. 6
Oper'ns 10
To 7
Operation Thread
Dftv.
Good
Totals
Labor Hrs. 1 1
Total Lab. Hrs. 2
Std. Hr. Prod.
Act. Hrs. Prod.
Mach. Hrs. 6
Hours Credit
Checked With C. C.
Rate
Cost
Quantity on Order 5000
Last Balance 5000
Balance To Do
Inspector's Signature
Earned For Day
Last Card Only
Card No. 1
Circle Last No.

FIGURE 74. TIME CARD COVERING USE OF TIME "FACTOR"



USE THIS CARD FOR PRODUCTIVE DAY WORK EITHER REGULAR, PREMIUM OR BONUS

FACTOR 3 2 3

6 15 30 45 7 15 30 45 8 15 30 45 9 15 30 45 10 15 30 45 11 15 30 45 12 15 30 45 1 15 30 45 2 15 30 45 3 15 30 45 4 15 30 45 5 15 30 45 6

Worker's No. 628

Date 1-9-19

Dept. No. | Worker's No. | Order Number | Mach. No. | Oper. No. | Class | Type | Pcs. Dftv. | Pieces Good | Mach. Hrs. | Labor Hours | Labor Cost | L C Oper

Dept. No. 1-6

Class 02 | Type 02

Order No. 1/2565

Description of Work 5/16" U.S.S. Plug Taps

Mach. No. 1026

Operation No. 6

Oper'ns 10 | To 7

Operation Thread

Dftv. | Good | Totals

Labor Hrs. 1, 2, 1

Total Lab. Hrs. 4

Std. Hr. Prod. | Act. Hrs. Prod.

Mach. Hrs. 10 | Hours Credit

Checked With C. C.

Rate | Cost

Quantity on Order 3000

Last Balance 3000

Balance To Do

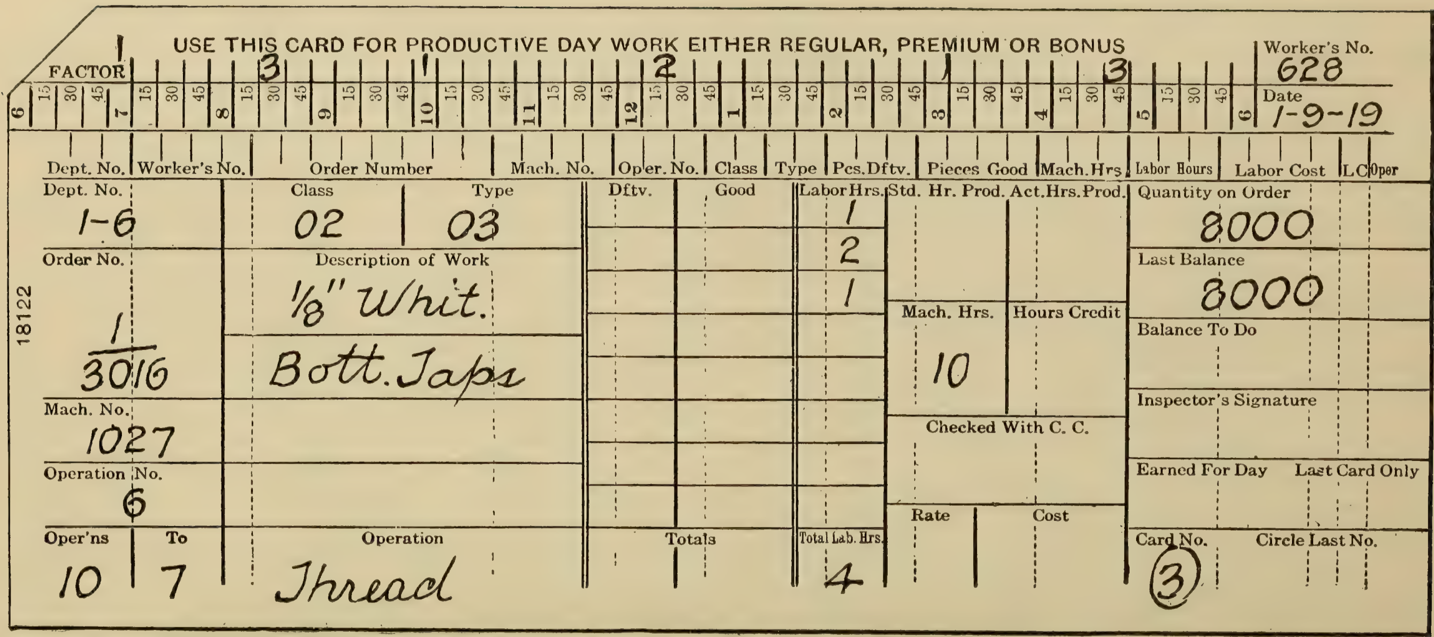
Inspector's Signature

Earned For Day | Last Card Only

Card No. 2 | Circle Last No.

18122

FIGURE 74A. SECOND TIME CARD OF GROUP OF THREE USING TIME "FACTOR"—REFER TO FIGURES 74 AND 74B


USE THIS CARD FOR PRODUCTIVE DAY WORK EITHER REGULAR, PREMIUM OR BONUS

FACTOR

Worker's No. 628

Date 1-9-19

Dept. No. | Worker's No. | Order Number | Mach. No. | Oper. No. | Class | Type | Pcs. Dftv. | Pieces Good | Mach. Hrs. | Labor Hours | Labor Cost | L C | Oper

Dept. No. 1-6

Class 02 | Type 03

Order No. 1/3016

Description of Work 1/8" Whit. Bott. Taps

Mach. No. 1027

Operation No. 6

Oper'ns 10 | To 7

Operation Thread

Dftv. | Good | Labor Hrs. 1, 2, 1

Totals | Total Lab. Hrs. 4

Std. Hr. Prod. | Act. Hrs. Prod.

Mach. Hrs. 10 | Hours Credit

Checked With C. C.

Rate | Cost

Quantity on Order 8000

Last Balance 8000

Balance To Do

Inspector's Signature

Earned For Day | Last Card Only

Card No. 3 | Circle Last No.

18122

Figure 74b. Third Time Card of Group of Three Using Time "Factor"—Refer to Figures 74 and 74a

card); Machines Nos. 1026 and 1027 continue. It is apparent that from 7 to 10 A.M. he is operating three machines and that his factor for that time is 3. To indicate this fact, draw a heavy line vertically at seven o'clock, and one at ten o'clock, placing a 3 between, as shown. On all three cards, the figure 3 is the factor and is to be divided into the hours between vertical lines. The result is one hour on each of the time cards, which is placed in column 18. No. 628 is still operating two machines, and while doing so his factor is 2. At three o'clock machine No. 1025 again comes back into service on the same order number. The same card is punched in and a heavy vertical line is drawn at three o'clock on all three cards. On cards Nos. 2 and 3 a 2 is placed between this line and the one previously drawn at ten o'clock, 4 hours is indicated between these lines, and when divided by 2 the result is 2 labor hours on each card, which is entered in column 18, second line.

492 When No. 628 has completed the day's run, or at six o'clock, it will be seen that from three to six he has been running three machines, and therefore his factor is 3, or 1 hour on each card, which is entered in column 18, third line. Summing up (space 19 in each card), we have 2 hours on card No. 1, 4 hours on card No. 2 and 4 hours on card No. 3, or 10 hours accounted for (1, plus 1, plus 2, plus 2, plus 2, plus 2 = 10). By taking the elapsed machine hours we have 6 hours on card No. 1, and 10 hours each on cards Nos. 2 and 3, which are entered in space 22.

493 Where the factor does not divide evenly into the elapsed hours (as 1¼ hours—factor of 3), arbitrarily divide the time into even 15-minute periods, as ½, ½ and ¼ hours.

494 Bonus or Premium Report. The Bonus or Premium Report, as illustrated in Figure 75, is a supplementary card on which the dispatch clerk records the information necessary for the Payroll Department to figure bonus or premium due to worker. This report is made out in duplicate and held by dispatch clerk until run is completed. The original is handed to the worker and the duplicate is forwarded with the goods to the inspector and then to the Payroll Department. This report does not at any time take the place of the regular time card, either piece or day.

495 On account of the various kinds of bonus and premium systems, the headings under "Records of Performance" have not been printed, and will have to be filled out as the occasion demands.

496 WORK ON OTHER DEPARTMENT STANDING ORDERS. The card used in reporting this class of labor is shown in Figure 76. For the present use the rubber stamp "Work on O.D.S.O." All labor consumed in working on other than

BONUS OR PREMIUM REPORT   PERIOD ENDING Week Jan. 9, 1919   Worker's No. 208
2-3 DEPARTMENT   WORKER'S NAME William Smith   Date 1-10-19
BASIS OF PAYMENT IS 30 Per Hour   0.01 Each Over

DEPT NO | WORKERS NO. | ORDER NO | OPE NO | CLASS | TYPE | PIECES GOOD | COST | L.C. | OPER

Order No. 22	Oprn. No	Pieces Made	Dftv.	Good	Bonus Earned	Signed O. K. By
30000	7	300		300	$ .60	

Class	Type	Records of Performance										
05	01	Date	Time	Pieces								
Description of Work		1-6	5	200								
Assemble		1-8	3	100								
1/8" W.S.O.D.			8	300								
					Bonus Due on 60 Pieces							
Heads												
Operation A'SBLE												

FIGURE 75. CARD FOR BONUS OR PREMIUM REPORT

the Home Department standing orders, except "Transfers," must be reported on this card.

Fill the card out as follows (consult sample on opposite page):

1 *Worker's No.* Use the worker's clock card number.

2 *Date.* Use date stamp and be sure that every card leaving the dispatch booth is dated correctly.

3 *Dept. No.* Place here the worker's Home Department number.

4 *Order No.* Use the standing code order number shown by the order accompanying the work, or consult code. This order number will consist of the divisional designation, the department and the standing code numbers, as: 2–13–27.

5 *Labor Hrs.* The number of hours as shown by the time scale.

6 *Rate.* Not to be used by dispatch clerk.

7 *Labor Cost.* Not to be used by dispatch clerk.

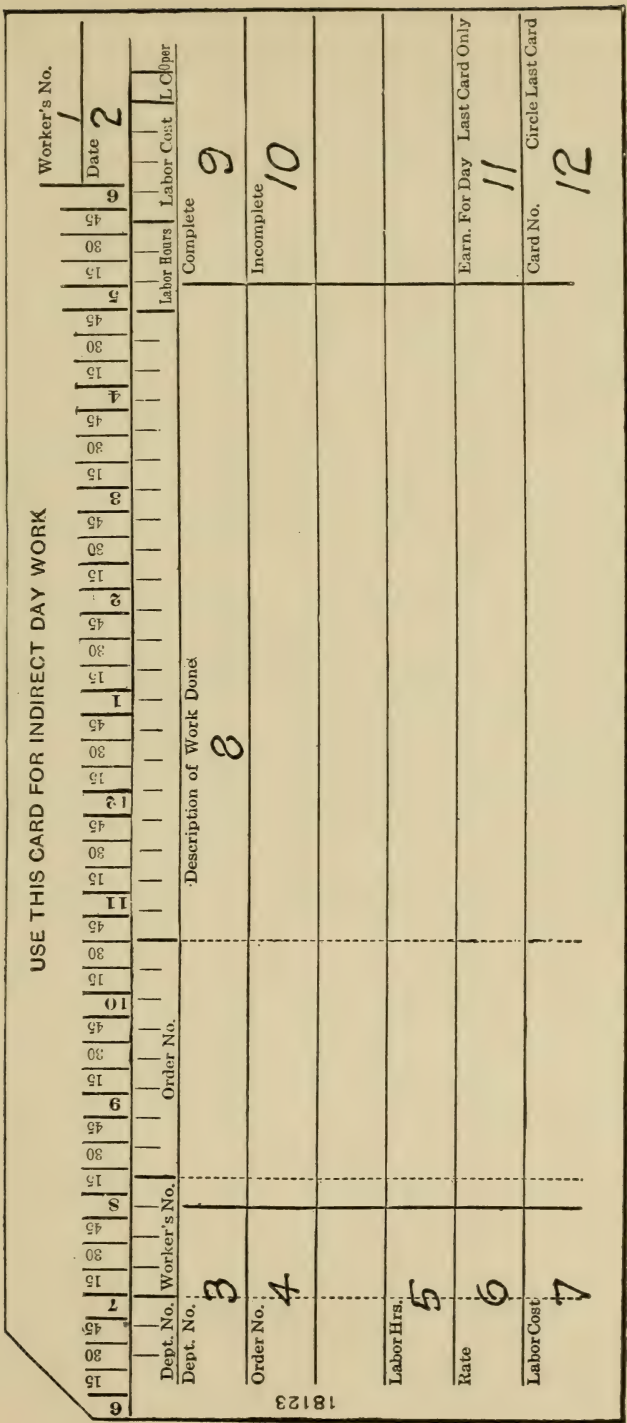


FIGURE 76. TABULATING CARD FOR INDIRECT LABOR

8 *Description of Work Done.* Place in these spaces a complete description of the work performed, and always state here the Maintenance Order number, as: Grinding, 28; cutters, Order No. 4539. If a machine is being repaired, its number must always be given, as: Repairing Machine No. 492.

9 *Complete.* If order is complete, check.

10 *Incomplete.* If order is incomplete, check.

11 *Earn for Day.* Not to be used by dispatch clerk.

12 *Card No.* Place in this space the card number. Number the workers' cards consecutively and place a circle around last number.

497 Indirect Labor. Indirect labor is that labor which cannot be charged direct to a production order or to another department standing order. It is expense labor and must be recorded with care.

498 The same information is required on this card as on the card just described; the *order number only* is different. The green ("indirect") card is used. (See Figure 76.)

499 Any labor chargeable to own departmental standing order code is to be reported on this card.

500 Idle Time Paid For. For allowance to workmen for idle time paid for, use Figure 77 and fill out same as Figure 76.

501 Idle Machine Time. This card is to be used in reporting idle machinery. Fill in as follows (see Figure 78):

1 *Date.* Use date stamp and be sure every card leaving the dispatch booth is dated correctly

2 *Department.* Place here the number of the department in which the machine is located.

3 *Machine No.* The number of the machine which is idle.

4 *Hrs. Idle.* The number of hours that a machine is idle.

5 *Regular.* If the machine is a general machine, place a cross (X) here.

6 *Sing. Pur.* If the machine is a single-purpose machine, place a cross here.

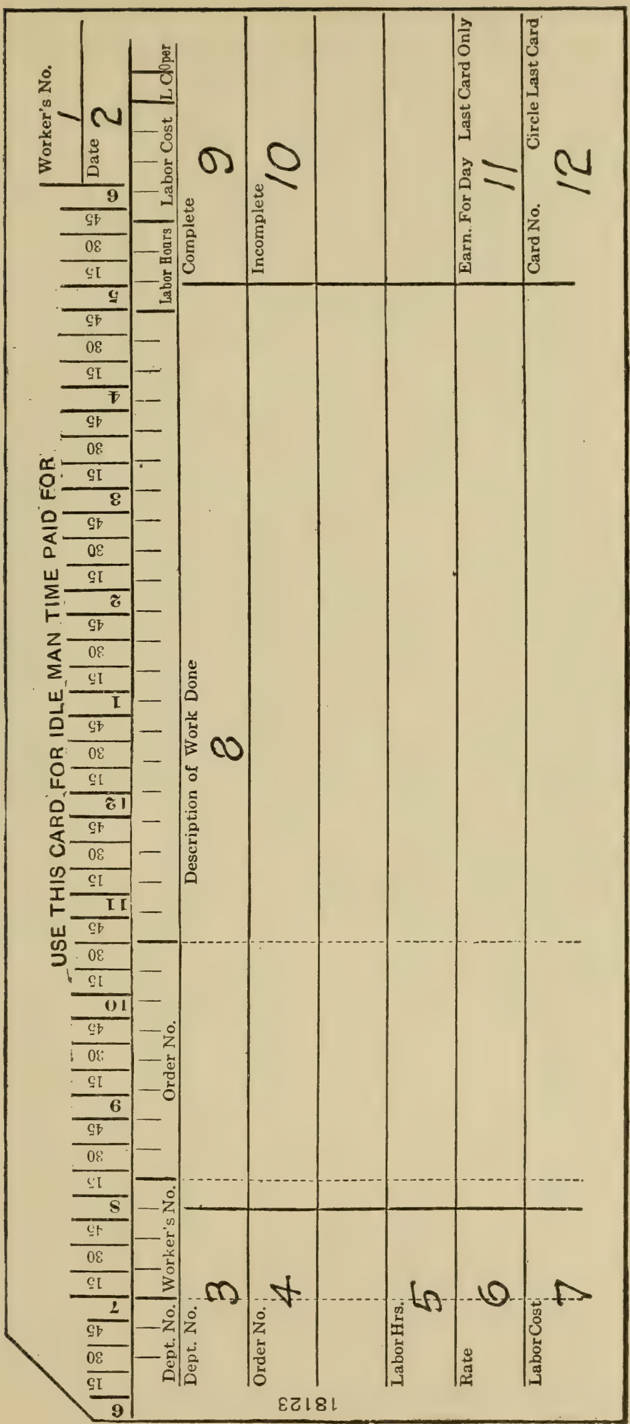


Figure 77. Tabulating Card for Idle Time Paid For

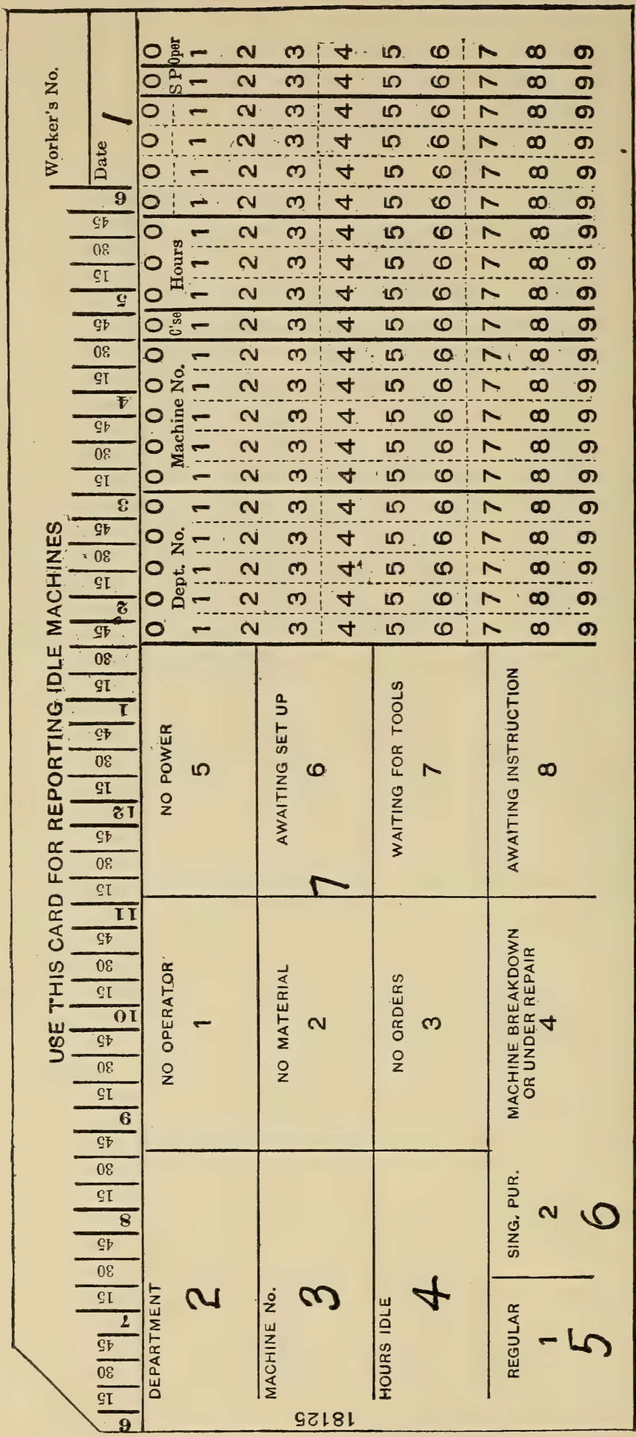


FIGURE 78. TABULATING CARD FOR IDLE EQUIPMENT

7 *Causes of Idleness.* Place a cross in the space representing the reason for the machine being idle.

502 Checking Cards. Ranking in importance with getting the information on the cards properly, is the checking of the day's cards the following morning. To facilitate this checking each dispatch clerk is provided with a list of the workers' numbers in the departments covered by that dispatch booth.

503 Cards are to be checked in the following manner: At five minutes past seven in the morning and at five minutes past one in the afternoon the dispatch clerk will gather up the cards remaining in the ''out'' rack and hold them in the dispatch booth. A worker who is late will have to report to the dispatch booth for his time card, and at that time the dispatch clerk will enter on the ''Late and Absent Report,'' shown in Figure 80, the worker's name, number, etc. At the end of the day the cards remaining in the dispatch booth will be the absent workers', and they will be entered on the same report.

504 From the issuance of authorizations for overtime the dispatch clerk will know what workers are on overtime, and will enter the time shown on the clock card in the ''Overtime'' Report, Figure 79. Night work is covered in the same manner.

505 For all other workers the dispatch clerk must show the standard ten hours' time. Both of these reports must accompany the time cards to the Payroll Department.

506 Transfers. When a worker is transferred temporarily, his time is to be turned in under the number of his own department, and with the cards from his own dispatch board. This does not mean that the dispatch clerk of his own department must fill out his cards, but that they must be checked and turned in to the Payroll Department with the balance of the department cards. The Home Department dispatch clerk must keep a memo card showing where the worker is. A rubber stamp reading ''Transfer to ——'' is to be used on the cards of the transferred workers.

507 General instructions covering the use of the above would be as follows:

1 Worker brings Identification and Move card (Figure 34, Chapter XIII) to dispatch clerk.

2 Dispatch clerk makes out time card, using the information appearing on the Move card, such as: order

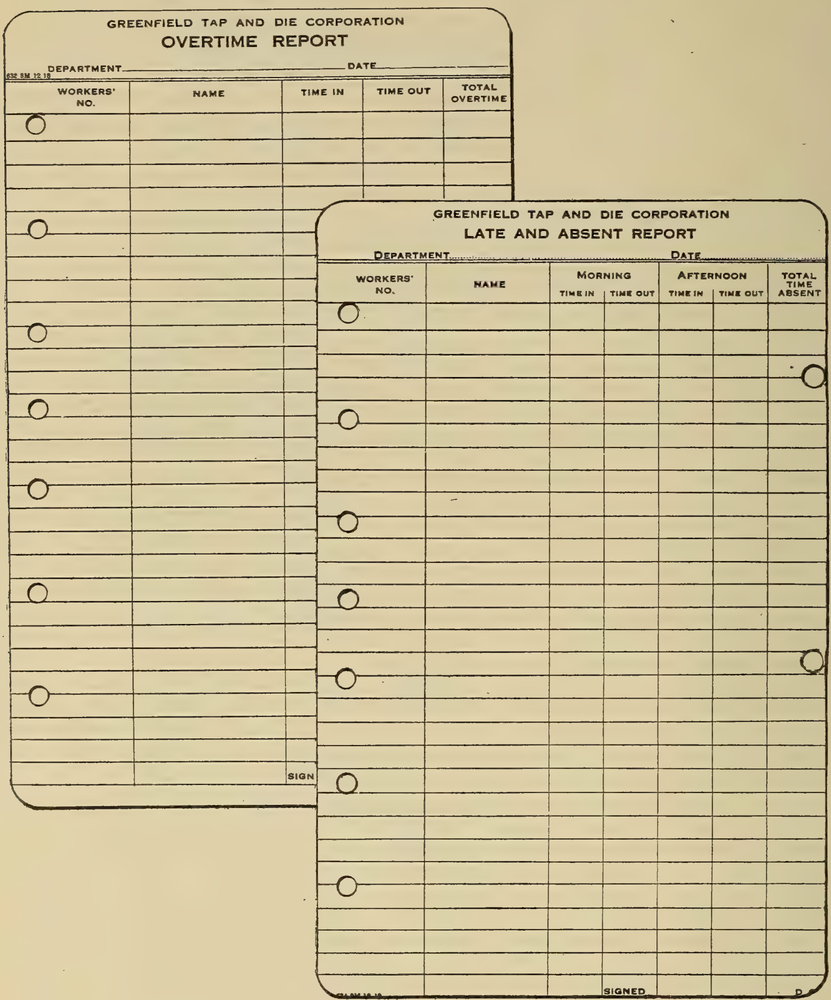


FIGURE 79. CARD FOR OVERTIME REPORT RECORD

FIGURE 80. ABSENCE REPORT RECORD

number, department, etc. Dispatch clerk punches time started and places card in rack under machine number.

The clerk also numbers the card in the space provided and in the manner described in the "Standard Instructions."

3 Worker finishes operation and reports to dispatch clerk.

4 Dispatch clerk removes time card from rack, punches stopping time, figures elapsed time, and punches in a new ticket for the next job, following the same procedure as in paragraph 2.

5 The time card is now passed to the inspector.

6 The inspector counts and inspects work and enters the quality, both good and defective. Returns card to the dispatch clerk.

7 Dispatch clerk rates piece work.

8 Each dispatch clerk will check time cards for full machine hours, full labor hours, place cards in numerical sequence by workers, and forward to chief dispatch clerk. See "Standard Instructions."

9 Chief dispatch clerk will keep a record of the time the cards are received.

10 Cards will then be passed to the control clerks, who use them in posting the control boards.

11 After control has been posted, the cards go to the progress clerks, who enter progress on the Progress cards.

12 The cards have now fulfilled their function in the production control work and will be forwarded to the payroll clerks. In the meantime, payroll clerks have posted their time exceptions (from the "Late and Absent" and "Overtime" reports) on their proof-sheets and are ready to check and extend the time cards.

13 Time and amount having been figured and posted, the cards are totaled by departments, placed in a box and forwarded to the Statistical Department, accompanied by a sheet showing the hours and amount for each department.

14 As cards are received by the Statistical Department they are recorded, counted by measuring (150 cards to the inch) and divided among the punch-key operators, a record being kept of what each operator punches.

15 Cards, after punching, are proved, with the amounts entered on the sheet accompanying the cards from the plant Payroll Department. If there is an error, it must be located and corrected.

16 Original cards are separated from the duplicate payroll cards, the latter dated, and originals and duplicates are placed in separate trays. The original cards are now at the disposal of the Cost Department for sorting, tabulating and filing.

17 The sorting required by the Cost Department is to be done by the Statistical Department, and is explained fully in "Standard Instructions."

18 The payroll cards are held until the entire week has been accumulated, are then sorted and become the care of the Payroll Department.

19 Errors which develop after the original cards have been sorted are to be accounted for on a separate card, which must be "O.K.'d" by the paymaster. No card is to be changed after filing.

508 The dispatch clerk, in handling the work above described, will be responsible—

A For the proper accounting of all working hours of the individuals in the department covered by that booth.

B For the entering on the job time cards of all information specified by the "Standard Instructions for Time and Cost Records" which have been issued or which may hereafter be issued.

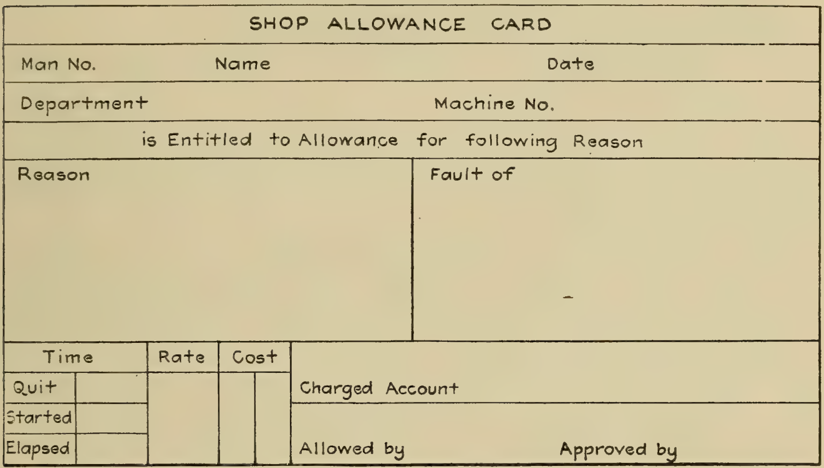
C For all supplies and tools which have been made a part of the dispatch-booth equipment.

D Time must be reported correctly. Remember that all workers are paid from the cards that you fill out. The greatest responsibility therefore is on the dispatch clerk, if there are errors in wages paid.

E When a worker starts an operation, punch the starting time and fill in the information called for as per the detailed instructions which follow. When a worker finishes an operation, punch the quitting time and write in the elapsed time in "total labor hours."

F Cards representing the entire time that a worker is present must be turned in, and they must be checked with the "Late and Absent" and "Overtime" reports for any deviation from the standard hours. These reports are made up from the clock cards and will be described later.

G It is very important that time cards be handled with care in order that no burred or jagged edges result. These cards pass through a machine which sorts and tabu-



SHOP ALLOWANCE CARD

Man No. Name Date

Department Machine No.

is Entitled to Allowance for following Reason

Reason

Fault of

Time

Quit

Started

Elapsed

Rate

Cost

Charged Account

Allowed by

Approved by

FIGURE 81. CARD FOR ALLOWANCES FOR DELAYS BEYOND WORKER'S CONTROL

lates by electricity, and jagged edges or imperfections in the cards will cause endless trouble.

H Cards used to report night work are the same as the day cards, but have the word "Night" stamped upon them.

I Overtime cards must be turned in separately from the regular standard hours. For instance, if a worker is working from 7 A.M. to 8 P.M., a separate card must be turned in for the time from 6 P.M. to 8 P.M.; this card must be stamped "Overtime."

509 The chief dispatcher will be responsible—

A For training dispatch clerks in the proper carrying out of their duties.

B For aiding the dispatch clerks in filling out time cards properly in regard to proper order numbers, machine numbers, workers' numbers, quantity, and, in fact, any of the information required by the card.

C For discipline of the dispatch clerks.

D For the providing of substitutes in case of accidents.

E For maintaining the schedule of card receipts into the Division Control Department so as to meet all requirements. The latest cards should be delivered not later than 9:30 A.M. the following morning.

F Adjusting differences caused by errors on the part of dispatch clerks.

510 If no time-card provision is made for allowing workers for delays beyond their control, Figure 81 can be used to advantage.

511 For charging workers with rejections for which they are responsible, or crediting them with rejections for which they are not responsible, rejection card (Figure 24, Chapter XII) can be used.

Chapter XVII

SCIENTIFIC DETERMINATION OF STANDARD HOURLY PRODUCTIONS

512 While we have recommended the use of estimated times in starting the installation of Graphic Production Control, and use this plan in our work, there are those who would prefer scientific determination of standard hourly productions, and for this reason a chapter on time and motion study has been included.

513 The chief functions of time and motion study are:

A The determination and elimination of faulty and unnecessary motion made by the men;

B The duplication by all men of the most efficient motions of the best men;

C The scientific determination of the best that a man can do, day in and day out, without injury to his health or condition of equipment;

D The proper division of responsibility, so that the men will not be asked to shoulder anything beyond turning out a product of good quality, without delays and annoyances, in the shortest time possible;

E The analysis and betterment of all faulty conditions;

F Rewarding the men in proportion to the skill and effort of each man.

514 No discussion would be complete without some reference to the variables in both the work and the worker, which are as follows:

As to the work, there are:

Size of unit to be handled.	Length of travel.
Weight of unit to be handled.	Position of worker.
Position of unit to be handled.	Rapidity of motion.
Method of handling.	Exertion called for.
Time consumed in making motions.	Automaticity of motions.
	Facilities furnished.

515 As to the worker, there are the following, according to Gilbreth:

Brawn.	Fatigue.	Size.
Contentment.	Habits.	Skill.
Earning power.	Health.	Temperament.
Experience.	Mode of living.	Training.

516 I have repeatedly called attention to these variables in the worker:

Concentration.—Focusing the mind on one thing.

Reason.—Ability to draw conclusions.

Interest.—Exciting attention in a particular thing.

Judgment.—The faculty of reasoning logically.

Energy.—Strength and power exerted.

Imitation.—The inclination to follow the lead of another.

Imagination.—The faculty of forming images in the mind.

Attention.—Application of the mind to a particular thing.

Loyalty.—Faithful acceptance of a trust.

Memory.—Power of retaining and reproducing mental impressions.

Initiative.—The power of commencing something without guidance.

Pleasure in work.—The faculty of being satisfied with our work.

517 Considering the various classes of motions and the variables in the motions, as against the physical and mental variables of the worker, *it takes more than experience to determine the best attainable standards as to time.* I well remember a case where a time of 9 hours for two men was

set for a piece of work which had previously taken 27 hours for two men. The shop foreman was naturally indignant, and the man who standardized the operation was looked upon as not knowing what he was talking about. The men under the constructive measures introduced, which did not involve the purchase of new equipment nor a change in the method of making, made the piece the first time in 11 hours, showing that the standard of 9 hours was within reason. It was simply a case of new methods of study and waste elimination against the usually accepted way.

518 The tools needed in making time studies are a decimal stop-watch with an accumulating control at the side of the winding stem, a small hand-counting machine and a clip-board on which to place the sheets for entering the facts revealed by the studies.

519 The method of making and using time studies is in a general way as follows:

A Resolve the work being studied into its various elements and movements.

B Secure the elapsed time spent on each element from the stop-watch.

C List the particulars concerning each element, with the time spent on same, on sheets prepared for the time study.

D Note on study all delays, useless motions, faulty conditions and whatever may be found in the way of inefficiency.

E Note such delays and interruptions as are unavoidable.

F Study for rest and fatigue of the worker.

G Note the best element or set of motions on any kind of work for duplication in other lines.

H Analyze the facts secured, determining the amount of preventable waste in time and ascertaining the proportion of allowed working time to the total time.

I From the data compiled standardize the operation as to sequence of elements, and prescribe, as far as possible, the procedure as to the motions.

J Set opposite each element, or set of motions, an allowed time which will consider rest, fatigue and unavoidable delays.

K Analyze the facts concerning waste and inefficiency, and outline constructive measures to correct the faults found.

L Index the data secured so-as to file it with information of like nature.

520 These studies can be made in two ways:

A By listing delays and faults as they are noticed.

B By throwing out all such information and simply recording net working time.

521 I prefer the method at *A*, for it is the analysis of such data that indicates the measures necessary to eliminate inefficiency.

522 There are also three ways of using the watch:

A Snapping the hand back to zero after each reading.

B Upon completion of each step, stopping the watch with the accumulating stem, reading the time and then starting again.

C Reading the time after each step, without stopping the hand.

523 Personally I prefer the method described at *C*, for in this way no time is lost in stopping and starting the watch. An operator soon learns to read the watch accurately without stopping it.

524 Studies can be made by listing the data pertaining to operations and eliminating all delays, or by listing delays and wastes noted and eliminating operation details. To get proper ratios, however, the starting and stopping time of observation should be noted from a regular watch, using the stop-watch for the time study. If, for instance, a study was begun at 9:15 and finished at 11:25, the elapsed time would be 2:10. If in this time you secured stop-watch readings covering the operation details amounting to 1:35, it would mean that there were delays amounting to 35 minutes, or 26.9 per cent., and the efficiency would be: 95 minutes, divided by 130 minutes, equal 73 per cent.

525 It is sometimes convenient to study each element by stopping the watch, reading time, entering information on

the sheets and at the same time snapping the hand back to zero for a new reading. When this is done slight errors will creep in and the regular watch should be used as just outlined. For instance, if the study consumed 320 minutes as shown by the regular watch, and the stop-watch reading totals 305 minutes, the correcting factor is found as follows: 320, minus 305, divided by 305, equals 4.9 per cent.

526 Many wonder how long a time study should take. This is a difficult question to answer. When starting a study it is next to impossible to determine just what will be unearthed in the way of data and facts. A study may take an hour or it may take several days. It all depends upon the work, the degree of complication and where the points obtained lead to. A safe rule to follow is:

527 "Take as much time to make a study as will result in sufficient facts on which to base conclusions which will withstand any attacks."

528 Some time ago I studied the making of candy. In watching the girls hand-dipping the centers, I was surprised at the rapidity and coördination of the motions, which were made with such swiftness and dexterity that the eye could scarcely follow them, and I thought it was going to be by far the most difficult task of time-study work I had encountered.

529 Close study soon revealed the fact that the motions were divisible into certain classes, each class having its own peculiar motions. By starting the watch when the girl began the motion and stopping it by using the accumulating stem when she finished the motion, then waiting until she started the same motion again, then starting the watch, I was able to get some valuable information. I saw, too, that there was a definite relation between one motion and another, and by studying the performance of a number of girls separately, to determine the peculiar motions followed by each, I was able to reach some important conclusions. Some girls made 10 motions per piece, others 5. The average was 8.8 motions. Standardizing showed that 7 motions were sufficient, and that through proper directions and training 6 motions would do the work as efficiently as 8.8 motions. When it is considered that the girls averaged

83,000 motions per day of nine hours, it can be seen how impossible it would have been to study the work in any other way.

530 To explain the method to follow for this class of studies, let us assume the following motions and times for six operators:

A

	Motions	Time
	1	2.0
M	2	2.1
	3	3.0
N	4	1.5
O	5	3.4
	6	1.2
P	7	2.4
Q	8	1.3
		16.9

B

	Motions	Time
M	1	2.2
N	2	2.2
O	3	1.9
P	4	2.1
Q	5	1.6
		10.0

C

	Motions	Time
M	1	2.4
N	2	3.1
	3	1.6
O	4	2.1
P	5	3.4
Q	6	1.6
		14.2

D

	Motions	Time
	1	2.4
M	2	1.6
	3	2.1
N	4	1.9
	5	3.4
O	6	2.0
	7	1.3
P	8	1.5
Q	9	3.0
	10	2.0
		21.2

E

	Motions	Time
	1	2.6
M	2	1.4
N	3	1.6
	4	2.1
O	5	1.4
P	6	2.2
Q	7	1.6
		12.9

F

	Motions	Time
M	1	1.8
	2	2.4
N	3	1.2
O	4	3.0
	5	2.0
P	6	1.6
Q	7	1.8
		13.8

531 Operator B had the fewest motions, 5 in number, designated by letters M, N, O, P, and Q. The motions of the other operators corresponding to these 5 motions have been marked with these letters, which means that those not marked are the unnecessary ones, capable of elimination through training and study. The average number of mo-

tions is 7.33; the lowest number, 5. Consequently efficiency as to motions is $\frac{5}{7.33} = 68.2\%$.

532 Let us now analyze the times covering the same motions, as follows:

	M	*N*	*O*
A	2.1	1.5	3.4
B	2.2	2.2	1.9
C	2.4	3.1	2.1
D	1.6	1.9	2.0
E	1.4	1.6	1.4
F	1.8	1.2	3.0
	Avg. 1.91	Avg. 1.91	Avg. 2.3

	P	*Q*		Total
A	2.4	1.3	M	1.91
B	2.1	1.6	N	1.91
C	3.4	2.0	O	2.30
D	1.5	1.6	P	2.20
E	2.2	1.8	Q	1.65
F	1.6			
	Avg. 2.2	Avg. 1.65		9.97

533 The average time of the motions per operator is as follows:

A	16.9
B	10.0
C	14.2
D	21.2
E	12.9
F	13.8
	Avg. 14.8

534 The efficiency as to speed of motions is therefore:

$$\frac{9.97}{14.8} = 67.3\%$$

535 The average of efficiencies 68.2% and 67.3% is

67.7%. Is this the real efficiency? First consider the following ratio:

$$\frac{\text{Standard} \quad 9.97 \text{ time} \times 5 \quad \text{motions}}{\text{Actual} \quad 14.8 \text{ time} \times 7.33 \text{ motions}} = 45.9\%$$

536 The product of the motion and speed efficiencies of 68.2% and 67.3% is 45.9%. Consequently this is the real efficiency *due to the law of dependent sequence.*

537 Speeding the Workers. I am sometimes asked if the stop-watch time study is aimed to speed up and drive the men. My answer is an emphatic No. It is a time-measuring device, not a speeding-up mechanism.

538 There are three ways to make a time study:

A By keeping the watch in the pocket so as to fool (?) the workman.

B Going up to a man and, without saying a word, flashing a watch and then beginning to make notes.

C Explaining to the men the purpose of the study; why the watch is necessary; what it all means; winning their consent, and even their interest and approval, and then making the study.

539 The first plan is the rankest kind of deceit, and the man who uses this method should not be surprised if the men in turn try to "go him one better." He deserves it.

540 The second plan is disconcerting to the men; arouses their antagonism and makes them feel that they are mere puppets to be observed without any right to protest or ascertain the purpose of the study. Only a man lacking tact and with no knowledge of human nature would attempt this sort of a study.

541 With the stop-watch I have studied coal-miners, molders, smiths, laborers, machinists, structural workers, and men and girls in other lines. I have yet to have my first difficulty, because my plan has been—

A Getting acquainted with the men.

B Explaining the use of the time study and the stop-watch.

C Securing the confidence of the worker.

D Explaining and discussing with the men the details of the work as the study progressed.

542 Determining a Fair Standard. Making a time study is one thing. Determining a fair standard therefrom is distinctly another. In the first place, what do we mean when we say "fair"? We talk about a fair day's work, a fair wage, a reasonable effort, a fair task, an average standard. Do we mean this fair for the best man, the average man, or the poor man? If for the average man, how are we going to classify and define him?

543 A writer on "Time and Motion Study" recently said that after arriving at a series of minimum times from studies made, some allowance must be made for rest, and then states: "This allowance can be determined for various classes of work only by experience, and will vary all the way up to 30 per cent. for piece-work prices and higher for premium and similar schedules."

544 Time study is valuable in efficiency campaigns from the standpoint of determining scientifically accurate time that should be taken to do work. Men experienced in making studies, however, are few in number, with a smaller number possessing the ability to dissect a study, outline betterments therefrom, prescribe the procedure and then standardize the time, with due provision for rest, fatigue, unavoidable delays, overcoming inertia, etc.

545 Considering these facts, any efforts directed toward reducing the work of constructively using time-study data to a more scientific basis, so as to take it out of the realm of judgment and experience solely, will mean much to those desiring to inaugurate time-study campaigns.

546 The claim is not made that this chapter will outline a basis for the scientific use of time studies, the making of which is already scientific in nature. It is only a step in the right direction. The experience to date has proved of such value that it was deemed advisable to outline what has been done in a small way, with the sincere hope that it will assist others who are working along the same lines, or who are in the dark and want to reduce it all to a basis which will withstand scientific attack.

547 What I offer may be contrary to what experience has taught others who are making a specialty of time-study work. A man must, however, be governed largely by his own experience, and this has taught me—

A That it would be decidedly unfair to ask a man to perform a task in the *best time* shown by properly made studies.

B That it would be decidedly unfair to the company to ask a man to perform a task in the *average time* shown by properly made studies.

548 In my own practice I have used a rule for determining a fair standard, as follows:

A fair standard is approximately one-half the difference between the best time recorded and the average time of the readings, added to the best time or deducted from the average time

—which means, in a more simple way, *the average of the average and best times.*

549 Assume that the following readings had been recorded:

Operation	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	Avg.	Best
1	20.6	17.3	22.1	16.5	20.1	14.3	24.7	18.5	19.3	14.3
2	12.4	8.4	14.2	7.1	12.9	10.4	8.5	7.6	10.2	7.1
3	27.3	22.1	28.4	21.7	32.8	23.4	26.5	21.6	25.5	21.6
4	12.7	13.4	15.5	9.6	11.1	8.9	11.4	10.6	11.6	8.9
Total .	73.0	61.2	80.2	54.9	76.9	57.0	71.1	58.3	66.6	51.9

550 A fair time, based on judgment and experience, would be about as follows:

Operation	
1	17.3 minutes from B
2	8.4 minutes from B
3	22.1 minutes from B
4	11.1 minutes from F
Total	58.9 minutes

—on which basis the efficiency is: 58.9, divided by 66.6, equals 89.9 per cent.

551 You will note that the standard determined upon in the case just cited was 58.9 minutes. The average time was 66.6 minutes, while the best time was 51.9 minutes. The difference is 14.7 minutes, one-half of which, added to the best time, equals 59.2 minutes, or nearly the same as the standard of 58.9 minutes.

552 To carry it a step further, assume that four different operations have been studied six times each, with the following results:

	1	2	3	4	5	6	Avg.	Best
A	20.1	18.7	16.4	24.9	14.3	17.1	18.6	14.3
B	24.5	27.8	15.3	17.5	20.2	18.9	20.7	15.3
C	35.2	30.4	37.5	26.4	31.5	29.5	31.7	26.4
D	10.3	15.4	9.7	8.6	12.5	14.9	11.9	8.6

553 Standardizing the time, without reference to rule or law, and then adding one-half the difference between best and average times to the best time, the results would be:

	From Figures without Rule	Using Rule	Differences
A	17.1 at 6	16.4	−.7
B	18.9 at 6	18.0	−.9
C	29.5 at 6	29.0	−.5
D	9.7 at 3	10.2	+.5

554 In using this rule, it should be understood that it applies to standardized operations only, and not to the time study as it is made. In other words, after making a study, eliminating delays, unnecessary motions and everything in the way of inefficiency, the several readings concerning a single operation, which as to method is now standardized, will show varying times, the average of which is to serve as the basis of comparison against the best time noted. To illustrate: The time-study readings may be 56 minutes; the best and average times of the standardized operation, 28 and 40 minutes respectively. The rule would not be

$$.5\ (56 + 28) = 42 \text{ minutes,}$$

but

$$.5\ (40 + 28) = 34 \text{ minutes.}$$

555 You may say at this point that I have used readings that do not show wide variations in time, and that as the extremes become more widely separate, altogether different findings would be the result. This feature has been considered. Readings can be of three kinds:

A A number of low times.
B A number of high times.
C A number of both high and low times.

556 We can assume the following as readings in minutes corresponding to *A, B* and *C:*

	A	*B*	*C*
	24	43	25
	33	46	31
	21	51	46
	48	92	83
	26	86	42
	54	45	26
	27	74	25
	49	83	63
	71	44	42
	33	47	58
	22	82	23
	52	77	71
Average	38.3	64.1	44.5
Best	21.0	43.0	23.0

557 Using the rule before outlined, we have:

A .... $.5\ (38+21)=29.6$
B .... $.5\ (64+43)=53.5$
C .... $.5\ (44+23)=33.7$

558 Analysis will show that while we allow a standard of 29.6 at A, there are several times well under this figure—24, 21, 26, 27, 22, with an average of 24. In other words, we have increased this average 23.3% $\frac{(29.6-24)}{24}$

559 As regards B, against the standard of 53.5 there are lower readings of 43, 45, 46, 44, 47, with an average of 45.

We increase this average 18.8% $\frac{(53.5-45)}{45}$

560 At C we have a standard of 33.7 against lower readings of 25, 31, 26, 25, 23, with an average of 26. This we increase 29.6% $\frac{(33.7-26)}{26}$

561 Consideration will show that as we are going to allow for rest, the standards determined are too liberal, and the variation so great as to warrant some steps aimed to ignore them.

562 *This we can do by working on the principle that all readings above the average should be ignored.*

563 In order to illustrate the working of this principle, we will again set down the figures shown under A, B and C, and throw out the times over the average:

	A		*B*		*C*	
	24	24	43	43	25	25
	33	33	46	46	31	31
	21	21	51	51	46	
	48		92		83	
	26	26	86		42	42
	54		45	45	26	26
	27	27	74		25	25
	49		83		63	
	71		44	44	42	42
	33	33	47	47	58	
	22	22	82		23	23
	52		77		71	
Average..	38.3	26.6	64.1	46.0	44.5	30.5
Best......		21.0		43.0		23.0

564 Now, using the rule previously outlined, we have:

A .... .5 (26.6 + 21.0) = 23.8
B .... .5 (46.0 + 43.0) = 44.5
C .... .5 (30.5 + 23.0) = 26.7

565 Comparing these standards against the average of the readings, which vary slightly from the best times, as

well as against the previous standards determined, we have:

	Previous Standard	Readings	Average	Revised Standard	Differences
A....	29.6	(24–21–26–27–22)	24	23.8	– .2
B....	53.5	(43–45–46–44–47)	45	44.5	– .5
C....	33.7	(25–31–26–25–23)	26	27.7	+1.7

566 That this refinement is in order and not a burden to the man will be appreciated when it is considered that some reason exists for the high readings, as, for instance, fault of man, over-exertion, conditions, etc.

567 It might be of interest to see how these rules work out in practice. An operation was studied with the following readings:

	In and Out	Glue	Cover and Trim
	.09	.15	.35
	.12	.17	.30
	.13	.16	.32
	.105	.175	.37
	.13	.17	.45
	.135	.15	.37
	.16	.18	.45
	.13	.15	.43
	.12	.20	.41
		.15	.41
			.41
Average..	.124	.165	.38
Low......	.090	.150	.30

568 It will be noted that there is no great variation in any of the readings. We can, therefore, determine our standard without dropping the times above the average, as follows:

In and out..................	.5 (.124 + .09) = .107
Glue	.5 (.165 + .15) = .157
Cover and trim............	.5 (.38 + .30) = .340
	.604

Standard (54 minutes + .604) = 89.4 pieces per hour.

569 The standard, which was based on judgment and experience, was made as follows:

In and out	.12
Glue	.15
Cover and trim	.32
	.59

Calculation (54 minutes + .59) = 9.15 pieces per hour.
Standard determined, 93 pieces per hour.

570 In another case—a turret-lathe operation—variations were found to be slight, so we will consider all the readings above the average, apply the rule, and see how it compares with the standard originally determined.

	In	1st Rough Cut	Change Tool	2d Rough Cut	Change Tool	Square End	Out
	.20	.35	.06	.13	.06	.26	.14
	.18	.37	.07	.21	.05	.23	.13
	.14	.33	.05	.19	.05	.25	.14
	.13	.29	.05	.19	.06	.23	.12
	.15	.34	.05	.19	.05	.22	.11
	.16	.30	.06	.19		.25	.12
	.14	.33	.05	.16		.26	.11
	.13	.28		.20		.24	.12
	.18	.31		.19		.25	.12
	.13	.29		.18		.19	.09
	.15	.30		.22		.23	.16
	.14	.30		.21		.27	.14
	.15	.32		.23		.32	.14
		.32		.22		.29	.12
		.34		.21		.26	
Average	.152	.31		.205		.25	.12
Best	.130	.28		.160		.19	.09

In	.5 (.152 + .130)	= .141
1st Rough	.5 (.31 + .28)	= .295
Change Tool		.050
2d Rough	.5 (.205 + .16)	= .182
Change Tool		.050
Square	.5 (.25 + .19)	= .220
Out	.5 (.12 + .09)	= .105
Total		1.043

$$\text{Standard} = \frac{54 \text{ minutes}}{1.043} = 51.8 \text{ pieces per hour.}$$

571 The schedule in effect calls for 55 pieces per hour. This the man was able to do.

572 REST AND FATIGUE. You have all read about Mr. Taylor's experiments in allowing rest to pig-iron workers. You have heard about the allowance of 10 minutes in each 1¼ hours to girls inspecting bicycle balls, which, in connection with other betterments, resulted in 36 girls doing the same work which previously had required 120 girls. I know of another case where, in making tobacco pouches, the production was increased from 275 to 550 per day through standardizing the work and allowing 20 per cent. rest to the operator. In my own experience, a job had been scheduled at 23 pieces per hour, and the workman over a reasonable period was unable to make the schedule. It was decided to analyze carefully so as to ascertain why he was unable to do so. The man, working as he usually did, produced 15.8 per hour during the morning of the day he was turned over to the writer. The following time study will show how rest was considered, and the influence it exerted:

	Rest Noon	Work	Pieces Produced	Total Pieces
1st hour		25 minutes	9	18
	5 minutes	25 minutes	9	
2d hour	5 minutes	27 minutes	10	20
	3 minutes	27 minutes	10	
3d hour	3 minutes	17 minutes	7	22
	3 minutes	17 minutes	7	
	3 minutes	17 minutes	8	
4th hour	3 minutes	10 minutes	5	23
	2 minutes	10 minutes	4	
	2 minutes	10 minutes	5	
	2 minutes	10 minutes	4	
	2 minutes	10 minutes	5	

Highest time recorded per piece, 3.0 minutes.
Lowest time recorded per piece, 1.55 minutes.
Best time for short run, 5 pieces in 10 minutes.

573 The operation was an intensely fatiguing one, yet you will notice that in the fourth hour after starting the study, or the ninth from starting time in the morning, *the worker did his best work.* The average pieces per hour for the four hours run was 20.7 as against 15.8 in the morning —an increase of 32.6 per cent. It may be well to say in this connection that the man subsequently attained an efficiency between 95 per cent. and 100 per cent. on this work.

574 Prescribing a rest of 5, 10 or 25 per cent. is one thing; it may be quite another to get the worker to take the rest when it should be taken, and for the proper length of time. To meet this condition the writer devised a "rest clock." These are made from ordinary dollar clocks, with new faces put on, and only one hand used. The man works when the hand is in the white space, and rests when the hand is in the black space.

575 After determining the allowance for rest, instead of changing the time standard decided upon, reduce the working minutes in the hour. If, for instance, your standard was 2.7 minutes per piece, and you find that the man is entitled to a 20 per cent. rest, the calculation would be

$$\frac{60 \text{ minutes} \times 80 \text{ per cent.}}{2.7 \text{ minutes}} = 17.8 \text{ pieces per hour.}$$

576 In closing this chapter, the author desires to refer readers who want to make a greater study of time-study methods, to "Time Studies," by Dwight V. Merrick, published by The Engineering Magazine Company.

Chapter XVIII

THE CONTROL BOARD AND ITS MECHANISM

577 The graphic control board, as developed by the author and his able assistants, is really a map showing the geography of the shop. It is the plant in miniature, showing, in one place, everything that one could see if he could visit, coördinate, and visualize every piece of equipment and working space, *at the same moment.* The board considers the constants and variables met with in the industrial plant. The variables are workers, materials and actual hours of work done. The constants are equipments and working places, the dates of the month, and the standards of performance, as expressed in hours or in pieces per hour. The task is to bring the variables and constants together, which we can do by considering work to be performed, or actually performed, according to equipment, by dates, expressing work, whether to be performed, or actually performed, as hours of work at standard rates of production.

578 All these constants and variables can be reconciled graphically by arranging, *opposite* equipment and working places, showing name and number, and *under* dates—

A *Work to do,* in terms of standard hours, and shown by graduated strip of paper cut to the proper length.

B *Material received,* in terms of the standard hours of work it provides.

C *Actual accomplishment* of operator in terms of the standard hours of work represented by the quantity he finishes.

—which, as will be seen, takes care of the six variables and constants.

579 The graphical scales used in Graphic Production

Control are generally of one coördinate—unit length—and represent several things, as follows:

A Production of operations stated in quantities per unit of time.

1 Quantities may be in units, weights, lengths, volume, standard cost or selling values.

2 Units of time, generally taken as an hour, or tenths of hours, or days.

B Amounts of raw and finished product, stated in quantities of parts, sub-assemblies or assemblies and supplemented by time datings, indicating the quantity of product scheduled, delivered or used.

1 Quantities of parts and sub-assemblies are generally stated in terms of the assembled product—that is, if four parts are required in one finished machine, the quantity is spoken of as one machine.

2 Assemblies decrease the quantities of parts or sub-assemblies, and use is made of an arrangement of vertical lines, crossing off the graphic representation of the number of parts or sub-assemblies.

580 The graphical scales in connection with control boards and charts are used in many ways, the conditions and peculiarities of the business in question determining the nature of the arrangement to use. Scales may be used in the following manner:

A A strip of cardboard with suitable graphical scales superimposed on it and held in position by metal pockets.

B Sheets of paper with a number of similar graphical scales printed on it, to be used in loose-leaf binders.

C Time cards with suitable graphical scales printed on them, of which only a part is used, the part in use being displayed by overlapping of cards and held in position on the control board in suitable pockets.

581 By letting white indicate the work to be done; green, the material ready for work, and black, the accomplishment, we have, in addition to furnishing a graphic presentation, facilitated the task of comprehending the real significance of the showing. By using colored signals (buttons or slid-

ers) to designate irregular conditions, the presentation becomes doubly valuable. As previously outlined, these signals are—

Brown—slow operator.
Purple—no operator.
Pink—machine down for repairs.
Yellow—no tools.
Green—no material or material low.
Blue—no work or work low.
Black—work behind schedule.
Red—rejections.
Red (with pointer)—completions.
White—memo.

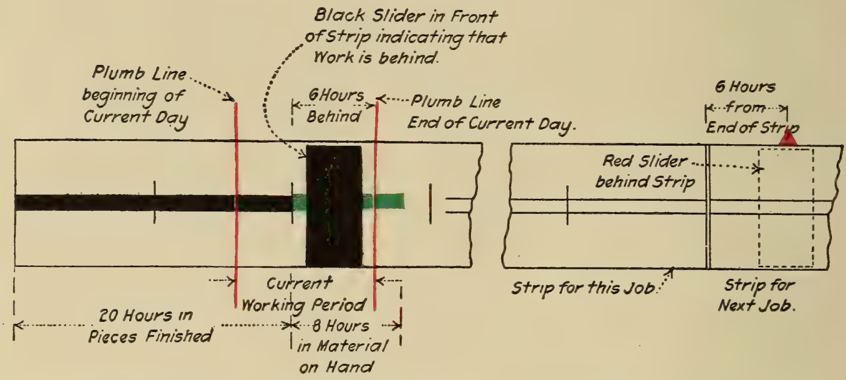


FIGURE 82. SCALE PLOTTING OF COMPLETION OF WORK USING STRIPS—WORK BEHIND

582 Figure 12, Chapter XI, illustrates the principle of the control board and should be reviewed in that connection. Figure 13, Chapter XI, gives the key to the signals.

583 "Yes," you may say, "the above is simple enough if all we had to consider were work done and material received, but how about rejections, overtime, setting-up time, replacements of rejected work, and the matter of anticipating completion of work, whether ahead or behind?"

584 The question is a fair one, and that it may be answered fully, a series of charts have been prepared which will prove of decided interest in this connection.

585 ANTICIPATING COMPLETION OF WORK. A shop man

not only wants to know what work is behind or ahead, *but he wants to know when to anticipate completion,* in so far as this may be possible, so as to rearrange his schedules accordingly.

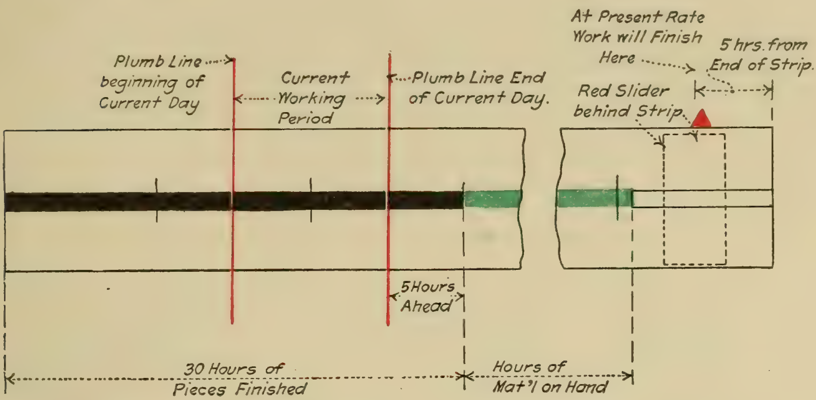


FIGURE 83. SCALE PLOTTING OF COMPLETION OF WORK USING STRIPS—WORK AHEAD

586 Figure 82 shows a condition where work is behind, as indicated by the black slider or marker between the plumb lines. In the case illustrated the job is 6 hours behind, *and assuming that the operator keeps up his present*

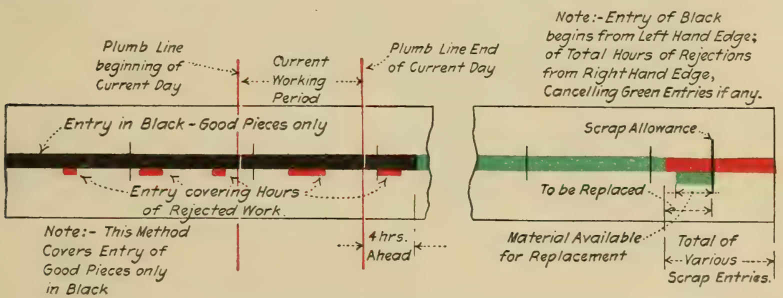


FIGURE 84. SCALE PLOTTING INDICATING REJECTIONS ON BASIS OF GOOD PIECES

speed, the completion will be 6 hours later than planned for. This we want to show graphically, and by providing a red slider or marker, with pointer, which can fit in the metal pockets placed *behind strips,* we can set the pointer under the anticipated completion time. As shown, the pointer is behind the strip covering the "next" job, and is 6 hours

from edge of strip for "this" operation and corresponds to the time the operation is behind. In Figure 83, we have the opposite of case in Figure 82. Here the job is 5 hours ahead, and the slider is placed accordingly.

587 *Cannot you see the value of this, you shop men who may be reading this? Imagine going up to a board and automatically picking off completion times!*

588 REJECTIONS. We want graphically to indicate rejections and provide for replacements where necessary. In Figure 84 we note that at different times during the course

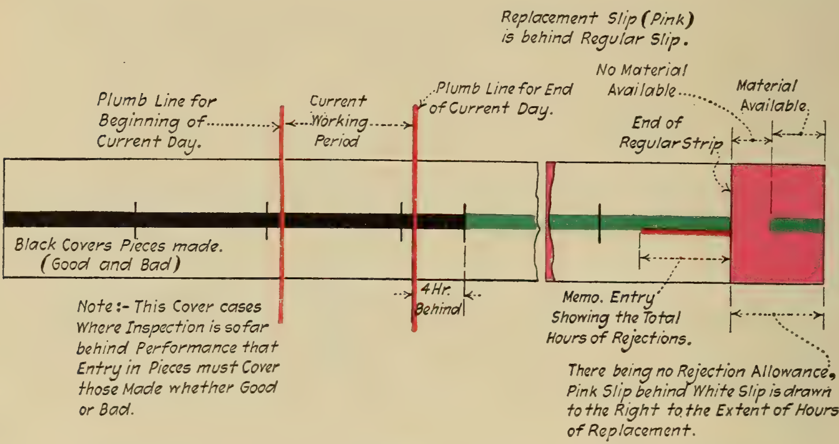


FIGURE 85. SCALE PLOTTING INDICATING REJECTIONS ON BASIS OF GOOD AND BAD PIECES

of the work there were rejections to the extent of hours as shown by the red lines under the black entry—five of them for 1, 2, 1, 3, and 2 hours each, or 9 hours in all. Obviously what a machine foreman or assembly foreman is interested in, is the *good pieces* produced, as good work only must enter into the final product. It is also obvious that bad work automatically cancels off a corresponding amount of material that is available, *and this we show by accumulating the hours of rejected work at the right-hand end of the strip, making the entries toward the left-hand edge.* If there is a scrap allowance plan in operation, the amount of the allowance can be shown by a heavy vertical black line. In the illustration there is a 5-hour allowance; but as there were 9 hours of rejections, 4 hours must be replaced, the

green entry under the red showing that material is available for only 3 of the 4 hours. *This green, with another hour of green, will be covered with black as the replacement is made.*

589 There are cases, however, as in some lines of steel foundry practice, where inspection cannot be made until some time after work of molding is completed, hence the black entry must cover total pieces made, which means good

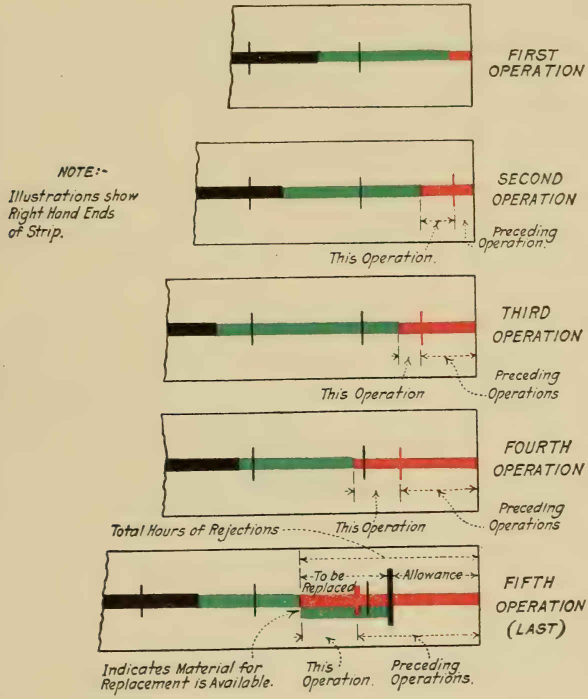


FIGURE 86. SCALE PLOTTING INDICATING REJECTIONS FOR CURRENT AND PRECEDING OPERATIONS

pieces and bad pieces (see Figure 85), with the result that at the end of the job black entries will cover green entries. Hence there would be no space for red on the horizontal graphic scale, so we mark a red line (memo entry), under the green, beginning at the right-hand edge and working toward the left. To take care of the replacement while the job is running, we place a *pink* strip back of the white one, drawing it to the length which corresponds to the hours of rejected work to be replaced, against which green entries

for material available are made, and replacement automatically taken care of at the proper time.

590 In the case of operations in sequence, it is most important not only to know the total hours of rejected work,

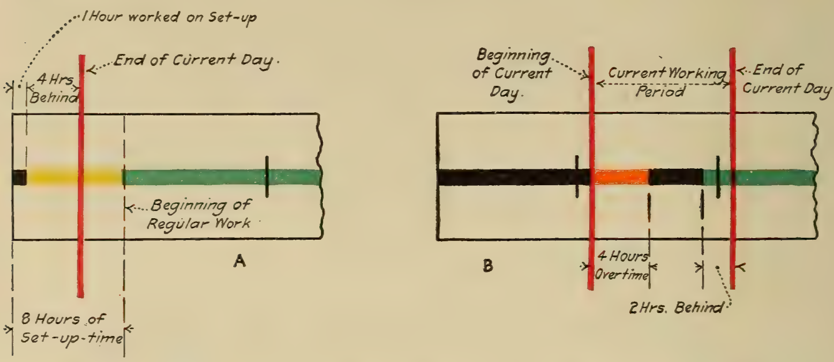


FIGURE 87. SCALE PLOTTING OF SET-UP TIME AND OVERTIME

but we should also know the hours of rejected work at each operation. In Figure 86 we have shown a series of strips covering 5 operations in sequence. At the first operation

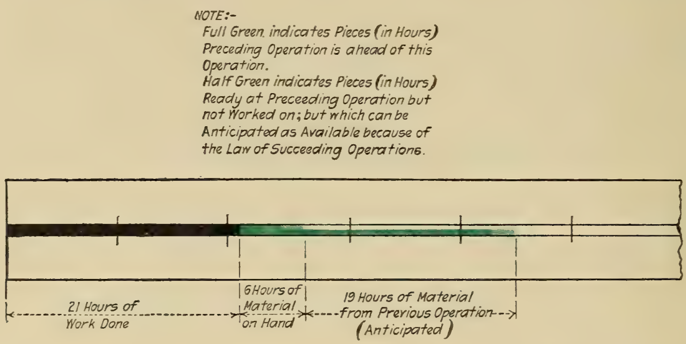


FIGURE 88. SCALE PLOTTING OF ANTICIPATED MATERIAL

there are 2 hours of rejected work, as shown in red. At the second operation, the 2 hours' time from the first operation is entered and 3 hours of rejected work for the second operation carried on to the left of this entry. Each succeeding operation shows, first, the total hours for the preceding operations, and, second, to the left, the total for "this" operation. On the strip for the last operation we find a total

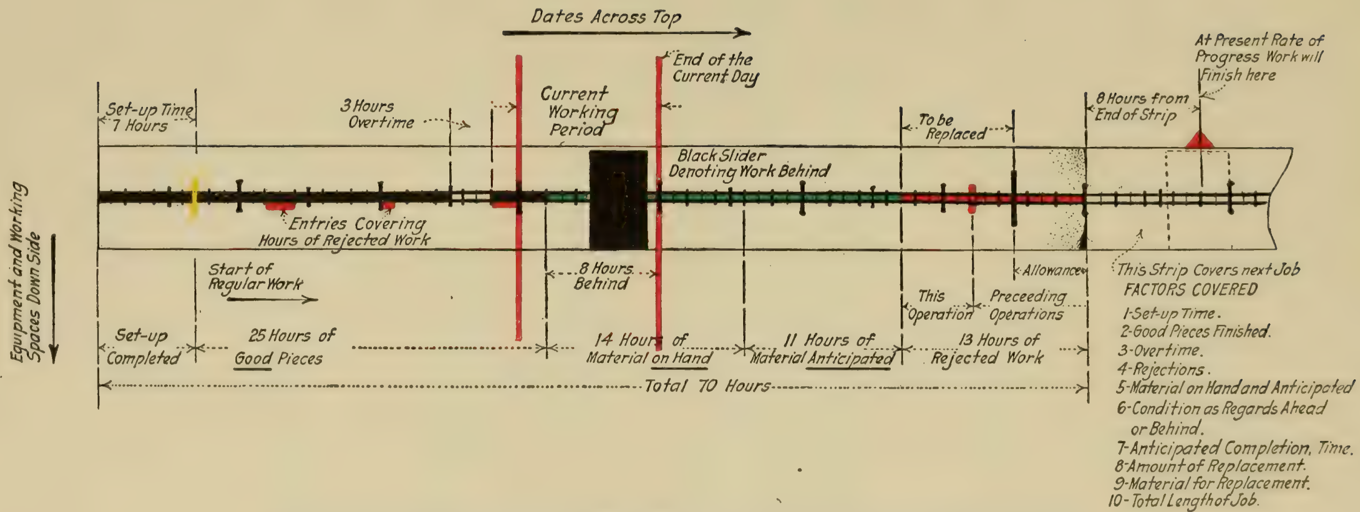


FIGURE 89. SCALE PLOTTING ASSEMBLING DATA ON A SINGLE STRIP

of 16 hours of rejected work, 9 from preceding operations and 7 for "this" operation. A scrap allowance of 8 hours, therefore, makes necessary a replacement to the extent of 8 hours, for which there is material available as indicated.

591 SET-UP TIME. To cover setting-up work previous to starting regular operation, which amounts to considerable in many shops, our strips must be cut to the length necessary to include this set-up time. In Figure 87 it is shown in illustration "A," in yellow, for 8 hours, against which 1 hour has been worked.

592 OVERTIME. Overtime is often resorted to, and we should have a means of distinguishing between regular time

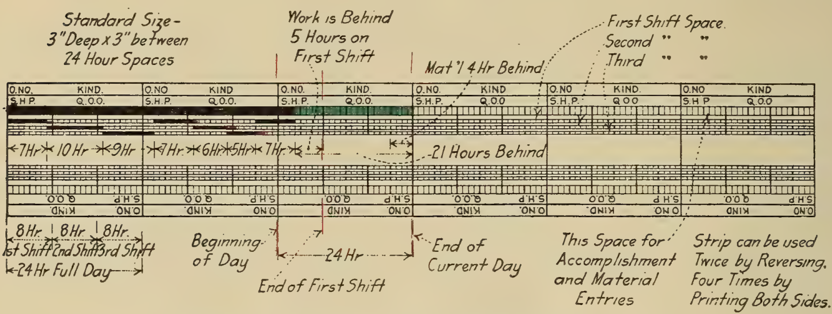


FIGURE 90. SCALE PLOTTING USING UNIT THREE-SHIFT STRIPS

and overtime; hence we use orange for overtime, as shown in Figure 87, illustration "B." The combined orange and black are credits covering accomplishment in labor effort. It should be understood, however, that orange does not cover cases where a machine, or a department, or the plant, works an extra shift. The matter of two and three shifts will be considered later.

593 MATERIAL FROM PRECEDING OPERATIONS. In cases where there are operations in sequence, it happens that many of them have ratios 1 to 1 or greater, by which is meant that for one hour performed at one operation, it releases one hour or more to a succeeding operation. For such cases as this it is generally considered—and safely, too—that material is available when work starts at the preceding operation. The purpose of the graphic presentation is to show actual conditions. Imagine what a shop man

would think on looking at a succeeding operation, which secured 3 hours' work for every hour finished at the preceding operation, and finding that there was no green entry indicating material available on the control board strip, even though the succeeding operation was then being worked on, and that at the preceding operation there was plenty of material available to feed the succeeding operation at the rate of 3 to 1!

594 In Figure 88 we have covered this by indicating the material *actually available* in full green, and material *anticipated* from a preceding operation, which has started and which will feed at a rate 1 to 1 or greater, in half green.

595 Assembly of Production Information on Strip. In Figure 89 we have shown a strip on which have been assembled about as many data, shown graphically, as will be found in the usual case in industry. For instance, the reading shows—

1 Length of job, 70 hours.
2 Seven hours of set-up time completed.
3 Regular time credit, 22 hours.
4 Overtime credit, 3 hours.
5 Three entries of rejections—2, 1 and 2 hours.
6 Job behind, as shown by black slider.
7 Actual material available, 14 hours.
8 Anticipated material, 11 hours.
9 Hours of rejected work, "this" operation, 5 hours.
10 Hours of rejected work, preceding operations, 8 hours.
11 Scrap allowance, 5 hours.
12 Replacement necessary, 8 hours.
13 No material yet available for replacement.
14 Anticipated completion time as shown by red slider back of strip for next operation.

596 In other words, the entire history of the operation in question is graphically shown, a study of which will indicate the great value of visualization. Imagine, if you will, how involved would be a verbal explanation, and the difficulty of keeping all the facts in mind!

597 Three-shift Basis. The strip illustrated in Figure

90 is designed to cover the three-shift plan of working, where the same work flows from shift to shift. By printing both sides as shown on one side, strip can be used four times by using, reversing, turning over and again using and reversing. The two lines at the top cover order number, kind of work, standard hourly production and quantity on order. The large horizontal graphic scale is for cumulative entries, *for all shifts,* of accomplishment in labor (black) and material (green). Under this scale are three smaller scales, the top for first shift, the middle for second shift and the lower for third shift.

598 It is obvious that if operator on first shift finishes only 7 hours of work as expressed in standard hourly productions, he is 1 hour behind, *and that there is 1 hour of material still unused.* The operator for the next shift starts from this point, but on the line for his own shift, and finishes 10 hours of work as shown (2 hours ahead), which throws 1 hour into the third-shift section, from which point the third-shift operator begins and completes 9 hours of work, or 1 hour ahead. Following this through to the end, it will be seen that we can tell *what* shifts are behind or ahead and how each day stands. In the illustration work is behind 5 hours on the first shift and 21 hours behind for the day,—against which, however, there will be an offset through the work of the second and third shifts, although material on hand for the third shift is not sufficient for the entire shift. Red entries covering hours of rejected work can be made for each shift as shown. The black entries for each succeeding shift can begin where the black entries stopped on the preceding shift, *as we are entering good pieces only.* If desired, the black entries can be started from the edge covering beginning of current day, regardless of black entries in preceding spaces.

599 No, a shift operator does not work on other shifts than his regular shift, as might be concluded from the markings. *The credits of each shift operator may, however, appear on the strips for the other shifts.* This possible misconception makes necessary a word of caution:

Do not confuse standard hours of actual pieces fin-

ished, which are credited on strips, with actual hours of actual pieces, which are not credited on strips.

600 We cut the strips for the pieces to be done in terms of the standard hours of work; we charge material as received to the strips in terms of the standard hours of work the material received provides, and we must therefore credit the worker or equipment in the same terms, so as to be able to note the variations when work is made at a *faster* or *slower* rate than the standard.

601 Standard Strips. In Figure 90 we show a standard three-shift strip, where work flows from shift to shift.

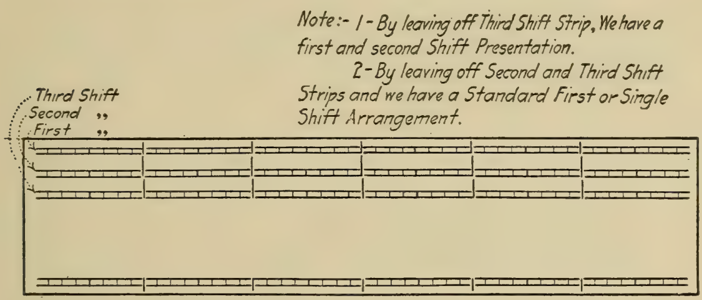


Figure 91. Three-shift Strips with Separate Scales Assembled

In cases where each shift works on different work, however, we need a graphical scale as shown in Figure 91, but we must have each strip separate, as shown in Figure 92, so as to manipulate shift strips at will and make the entries on each strip complete in themselves. In designing these strips for the three shifts, we provided for the following:

1 To make the first-shift strip standard for all single-shift plants.

2 To make the second-shift strip standard for all cases where machines, departments or plant may work a second turn.

3 To make the third-shift strip standard and to go in front of the other two strips when using strips for three shifts.

602 It should be said that the strips illustrated in

Figures 90, 91 and 92 are for metal pockets and not for slides on wood, as used in the earlier type of boards.

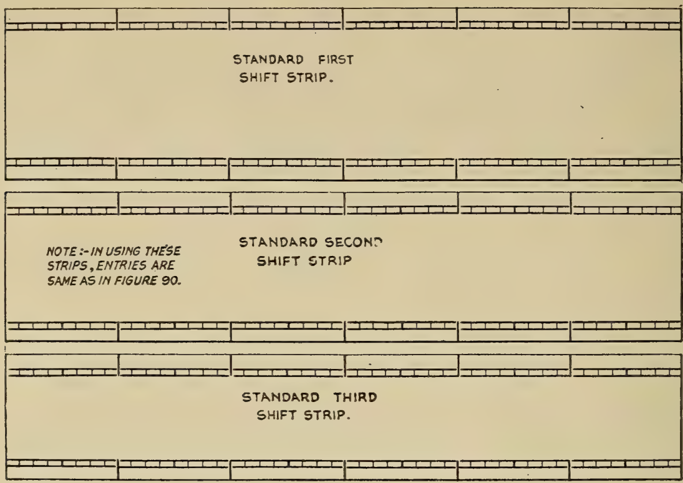


FIGURE 92. STANDARD SEPARATED SHIFT STRIPS

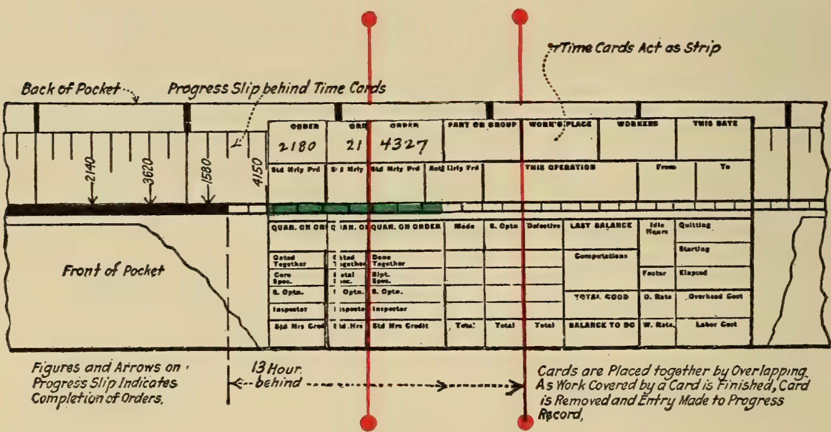


FIGURE 94. ARRANGEMENT OF SCALES USING CARDS IN PLACE OF STRIPS

603 SECOND-SHIFT BASIS. After studying the details of the three-shift plan and the information regarding the various strips, it can easily be seen how the second shift is handled in a plant.

604 A TYPICAL SCHEDULE. In Figure 93 is an illustra-

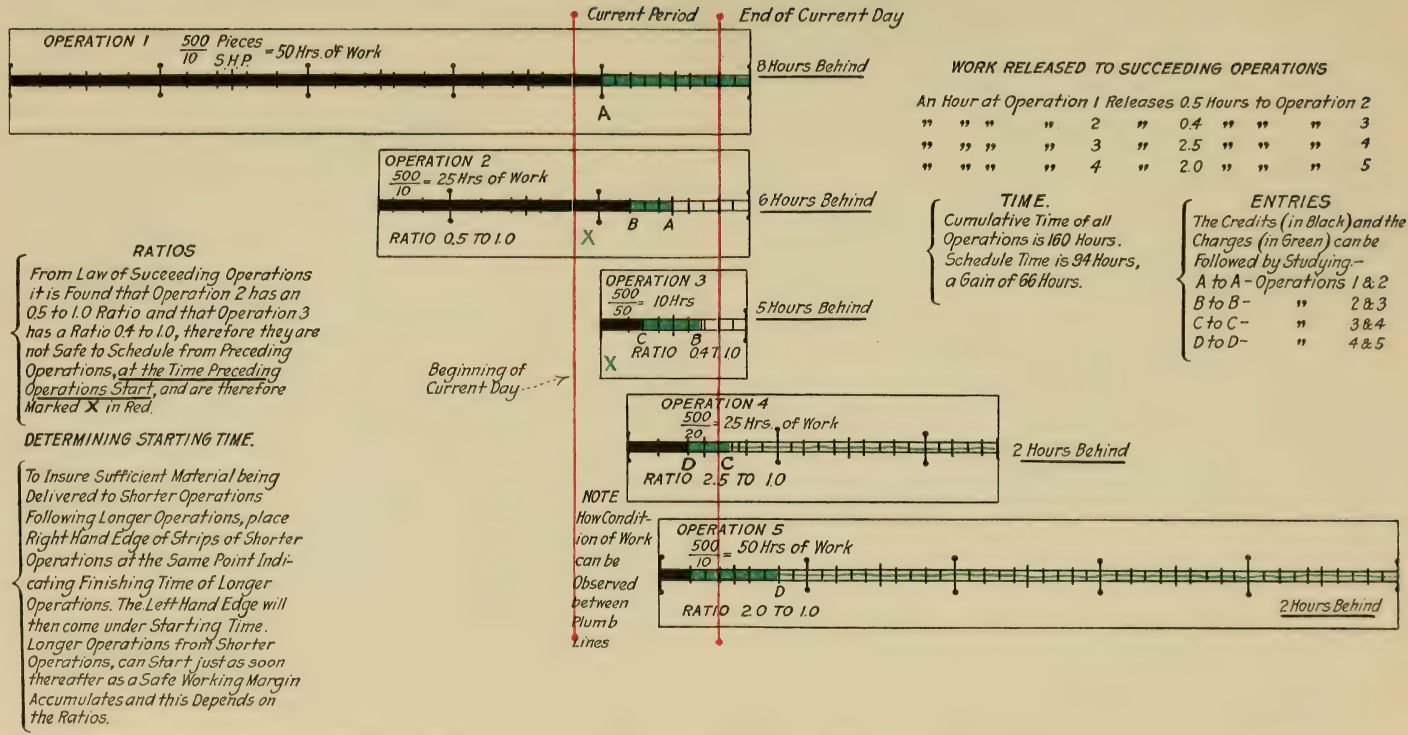
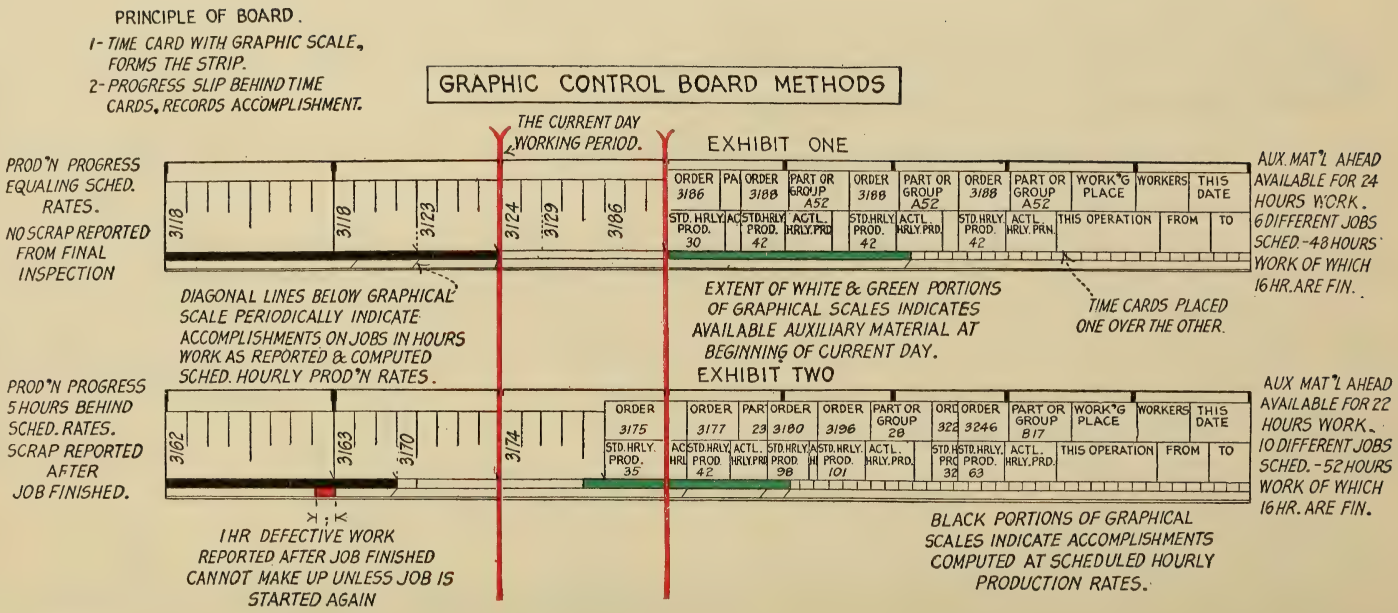


FIGURE 93. SCALES AND STRIPS SHOWING TYPICAL SCHEDULING


GRAPHIC CONTROL BOARD METHODS
PRINCIPLE OF BOARD.
1- TIME CARD WITH GRAPHIC SCALE, FORMS THE STRIP.
2- PROGRESS SLIP BEHIND TIME CARDS, RECORDS ACCOMPLISHMENT.
THE CURRENT DAY WORKING PERIOD.
EXHIBIT ONE
PROD'N PROGRESS EQUALING SCHED. RATES.
NO SCRAP REPORTED FROM FINAL INSPECTION
3118
3118
3123
3124
3129
3186
ORDER 3186
STD. HRLY. PROD. 30
ORDER 3188
STD. HRLY. PROD. 42
PART OR GROUP A52
ACTL. HRLY. PRD
ORDER 3188
STD. HRLY. PROD. 42
PART OR GROUP A52
ACTL. HRLY. PRD.
ORDER 3188
STD. HRLY. PROD. 42
PART OR GROUP A52
ACTL. HRLY. PRN.
WORK'G PLACE
THIS OPERATION
WORKERS
FROM
THIS DATE
TO
AUX. MAT'L AHEAD AVAILABLE FOR 24 HOURS WORK. 6 DIFFERENT JOBS SCHED.-48 HOURS WORK OF WHICH 16 HR. ARE FIN.
DIAGONAL LINES BELOW GRAPHICAL SCALE PERIODICALLY INDICATE ACCOMPLISHMENTS ON JOBS IN HOURS WORK AS REPORTED & COMPUTED SCHED. HOURLY PROD'N RATES.
EXTENT OF WHITE & GREEN PORTIONS OF GRAPHICAL SCALES INDICATES AVAILABLE AUXILIARY MATERIAL AT BEGINNING OF CURRENT DAY.
TIME CARDS PLACED ONE OVER THE OTHER.
EXHIBIT TWO
PROD'N PROGRESS 5 HOURS BEHIND SCHED. RATES.
SCRAP REPORTED AFTER JOB FINISHED.
3162
3163
3170
3174
ORDER 3175
STD. HRLY. PROD. 35
ORDER 3177
STD. HRLY. PROD. 42
ACTL. HRLY. PRD
23 3180
PROD 98
ORDER 3196
STD. HRLY. PROD. 101
PART OR GROUP 28
ACTL. HRLY. PRD.
322 3246
32 63
PART OR GROUP 817
ACTL. HRLY. PRD.
WORK'G PLACE
THIS OPERATION
WORKERS
FROM
THIS DATE
TO
AUX. MAT'L AHEAD AVAILABLE FOR 22 HOURS WORK. 10 DIFFERENT JOBS SCHED.-52 HOURS WORK OF WHICH 16 HR. ARE FIN.
1 HR DEFECTIVE WORK REPORTED AFTER JOB FINISHED CANNOT MAKE UP UNLESS JOB IS STARTED AGAIN
BLACK PORTIONS OF GRAPHICAL SCALES INDICATE ACCOMPLISHMENTS COMPUTED AT SCHEDULED HOURLY PRODUCTION RATES.

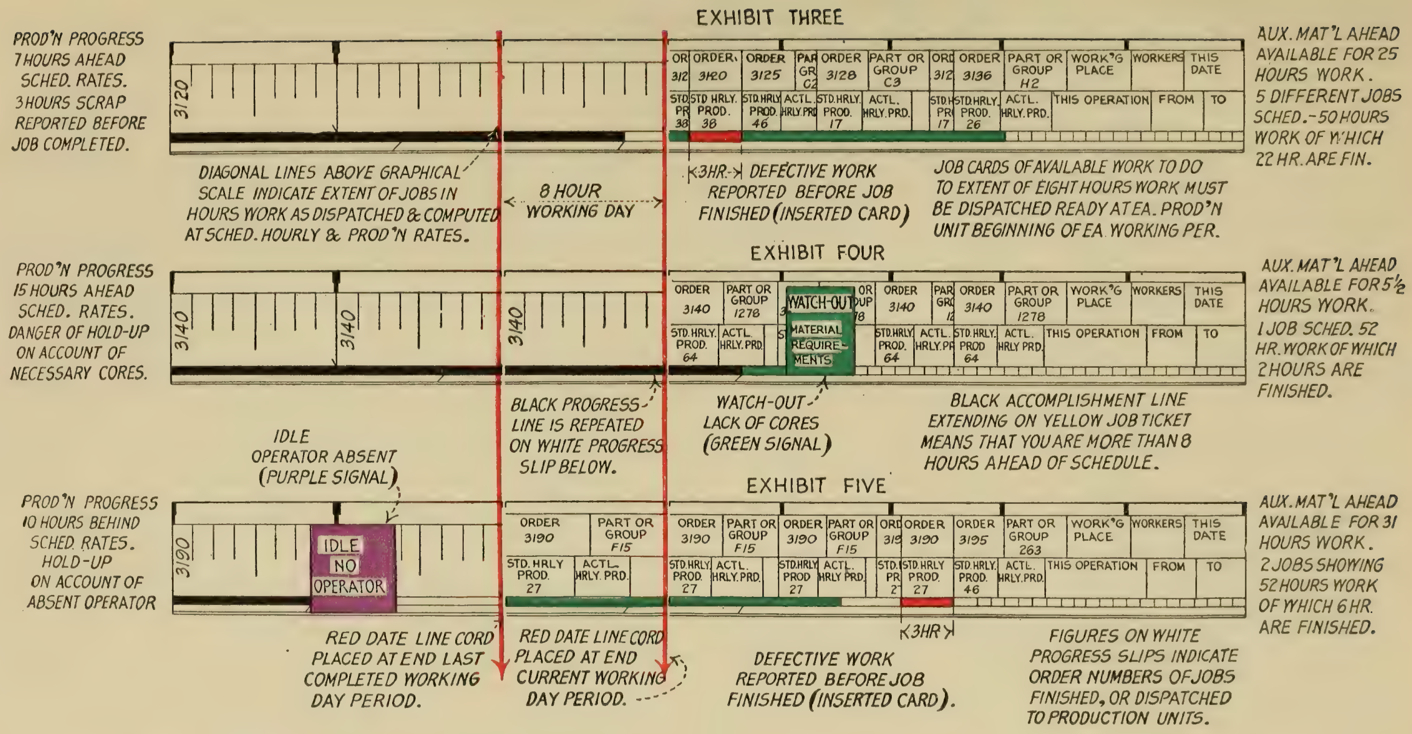


Figure 95. Scale Plotting in the Form of an Elaboration of the Use of Cards in Place of Strips

tion covering a typical scheduling of operations as they would appear on the control board, which considers the matter of ratios, starting times, charges for material and credits for labor effort, as well as progress of work. The chart will be found clear enough to be considered self-explanatory, making a detailed description unnecessary here.

605 Time Cards as Strips. Figure 94, which is also self-explanatory, illustrates still another principle of the use of the boards, in that the time cards themselves act as strips, behind which are progress slips on which are entered accomplishments, and which act more or less as a permanent record. Figure 95 elaborates to a considerable extent the principle illustrated in Figure 94, a study of which will prove profitable. In actual practice we are in favor of the strip board, with time cards as a separate proposition. In cases, however, where the operations are short, or where there are frequent changes or unusual complications, time cards can be used to advantage as strips.

606 Construction of Boards. A few words with reference to the construction of the control boards are in order, that the reader may have a clear idea of the control mechanism. Figures 96 and 97 cover a single and double control board, which can be used either as a strip board or with cards as the strip. The single board is designed to cover cards used for mechanical tabulation, while the double board covers cards 3×5 inches in size. The board is standard for single, double or triple shifts.

607 Description of Boards. Graphical scales on control boards are arranged so that fifty production units or classes of operations are handled by each board. Each production unit takes up 1½ inches vertically; length of vertical coördinate, or fifty units, being 75 inches. Workers' Job and Time Reports, on which a graphical scale has been incorporated, are used for posting scheduled work. The mechanism of the board consists of overlapping sheet-metal pockets suitably arranged so that 1½ inches of Workers' Job and Time Reports are exposed. Exposed part of time report contains graphical scale and most pertinent data, such as: order number, department, working place,

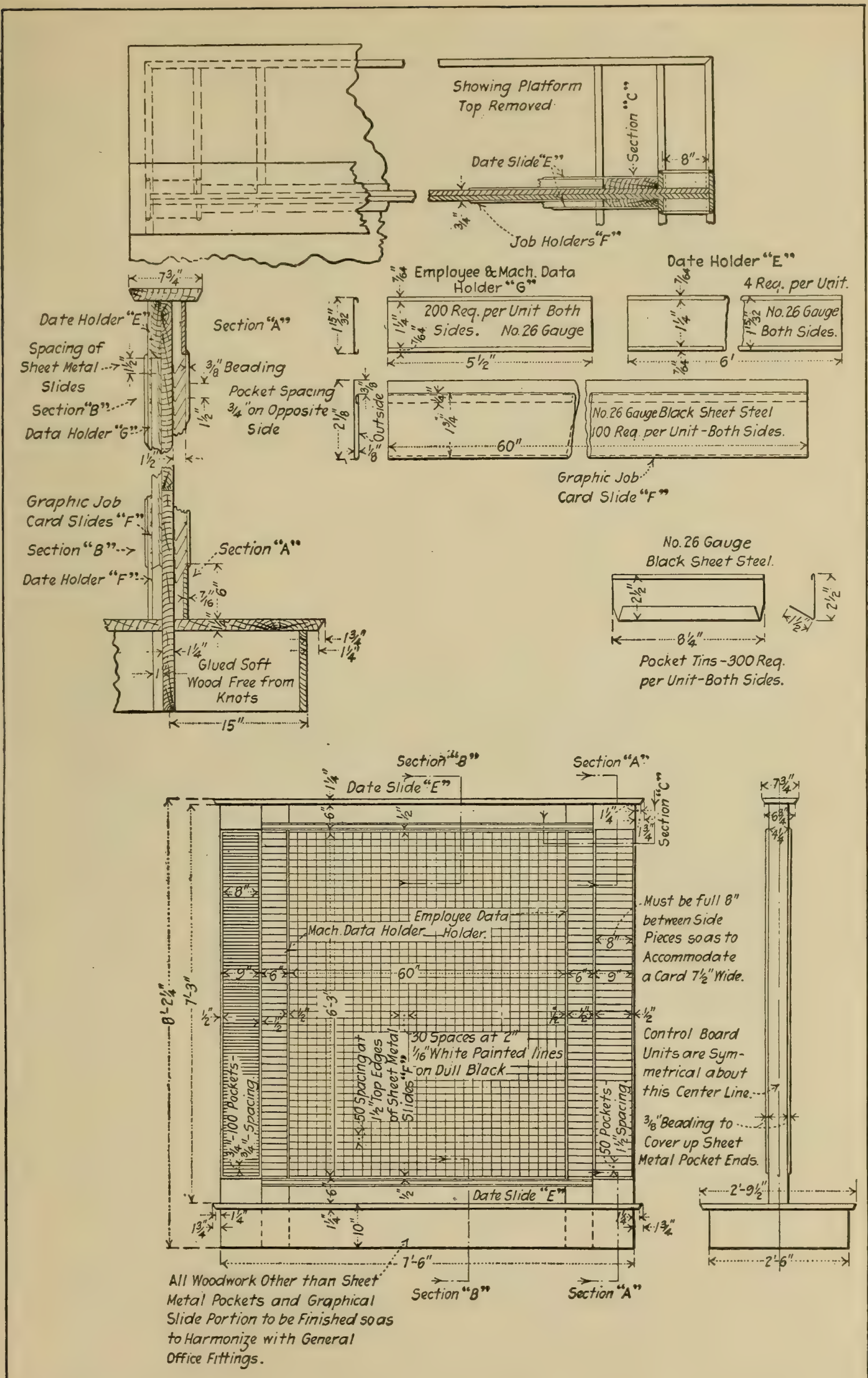


FIGURE 96. DETAILS OF A SINGLE CONTROL BOARD

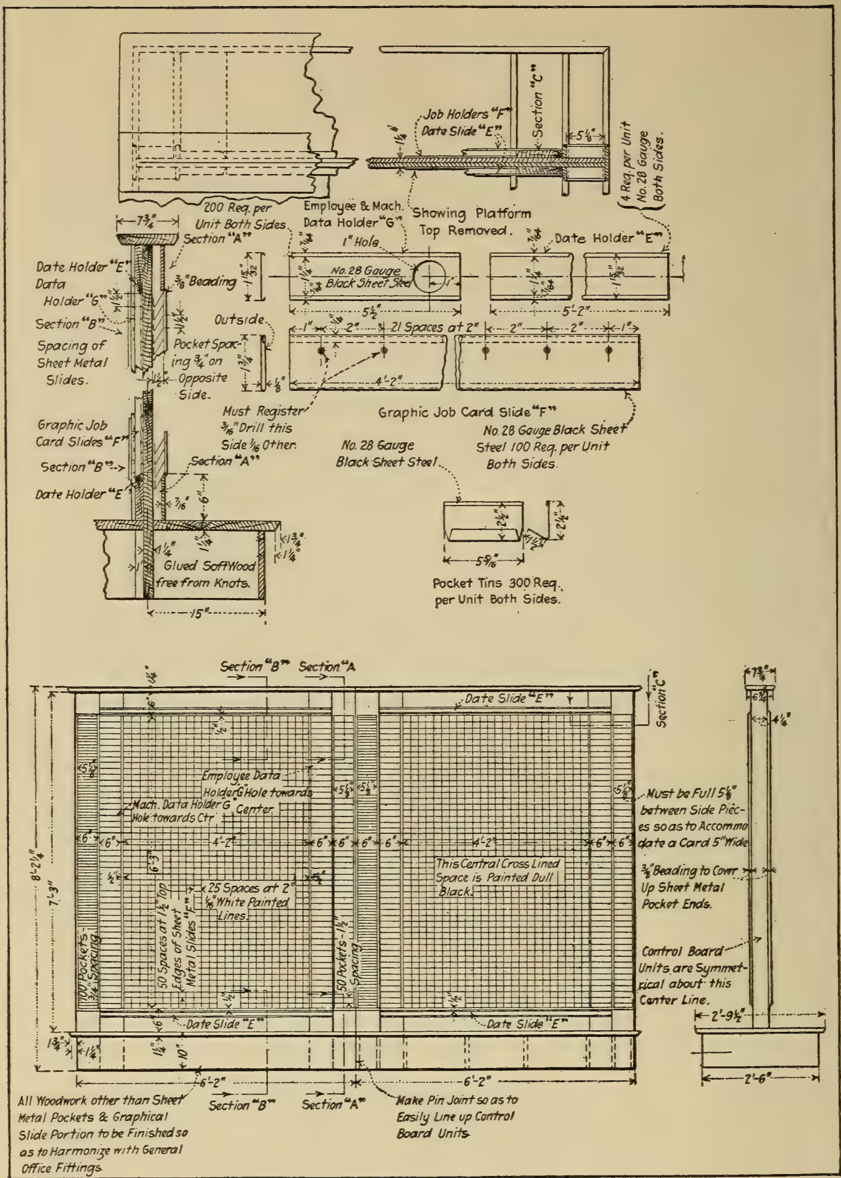


FIGURE 97. DETAILS OF A DOUBLE CONTROL BOARD

worker's number, helper's number, part number, date, sequence of tickets, standard hourly production, operation and routing from and to.

608 Horizontally, graphical scales are of a length of 50

inches, and, with each hour represented by $\frac{2}{10}$ inch, make it possible to display on board 250 hours' work ahead at all times. The 250 hours are divided into five equal fifty-hour spaces by four vertical black rubber cords of about $\frac{3}{16}$-inch section, which extend from bottom to top of board. Each fifty-hour space is, in turn, divided into ten-hour spaces by black cords of about $\frac{1}{16}$-inch section. Contrast of black cords with white surface of posted Workers' Job and Time Reports gives an easy and quick method of visualizing amount of work ahead of each production unit.

609 At top of board, a date scale for current month, as well as progressing days of following month (when that space becomes available), is arranged. Each working day is indicated in metal date slide by a strip of cardboard whose length indicates regular number of working hours in given day period. Take a case of an $8\frac{1}{2}$-hour period for five days of week, and $5\frac{1}{2}$ hours on Saturday. Cardboard date strips would accordingly be 1.65 and 1.05 inches long, respectively.

610 As each day progresses, two red rubber cords of about $\frac{3}{16}$-inch section, which also extend vertically from bottom to top of board, are moved along one day space, indicating graphically beginning and ending of the current working day. Work finished, ahead of red cord for end of current day, is work ahead of schedule, and work unfinished, behind red cord, is work behind schedule. Comparisons made possible by red date line and black fifty- and ten-hour period lines give all time relationships required.

611 Each production unit or class of work is identified by $1\frac{1}{4}$-inch strip of cardboard, five inches long, placed in metal slides on both right and left hand of $1\frac{1}{2} \times 50$ inch spaces devoted to machines, benches, floors, or general labor operations. These identification cards give number of production unit, department location, its descriptive name, range and specialty. In this manner it is possible to identify quickly the entire arrangement of production units.

612 Against each production unit, or class of operation, certain workers must be scheduled. It is of paramount importance that it be known where each employee works as well as what he does. This condition is supplied by one-inch round yellow tags, giving each employee's clock num-

ber, as well as symbol of general class of operations each is skilled to do. These employee identification tags are suitably located on pegs opposite machine, bench, floor or general labor operation which they handle.

613 Only tags of employees, on hand and working, are placed on control board. Where an employee is absent for an unknown reason, ill, on vacation, or away on company business, his tag is placed on Absent Employee Board under proper designation. Energetic follow-up of labor requirements is of great importance in any adequate production control plan, particularly during the present times of stress in the labor world.

614 On left-hand edge of control board, opposite each production unit, are arranged two distribution pockets. Current finished Workers' Job and Time Reports are filed by date in lower of each pair of pockets against production unit where work was performed. Before filing, however, all necessary calculations on job reports, registrations on progress records, and checking with clock cards have been made.

615 The upper of two distribution pockets, opposite each production unit, is utilized for the purpose of holding production data. This is for convenient and systematic reference with regard to work scheduled on each production unit.

616 On right-hand side of control board, opposite each production unit, there are also distribution pockets. These are utilized for Workers' Job and Time Reports in excess of those posted graphically. Periodically, as space becomes available, they are transferred to board and placed in proper sequence.

617 It must be understood that these excess jobs placed in right-hand distribution pockets are arranged in the sequence in which it is desirable that work be done. Jobs to be done first are in front, and so on in sequence to the last job filed in pocket.

618 S. H. P. Chart. In order to guard against the criticism that the calculations necessary to determine standard hourly productions, as material is received and work completed, will call for an enormous amount of clerical work,

let me suggest that a chart be made with pieces received or made across the top and pieces per hour down the side. The scale can be 100 across the top and 50 down the side. If the pieces were 830 and the S. H. P. were 30 per hour, the rule would be to multiply the S. H. P. for 100 by 8 and add the S. H. P. for 30.

619 Important Rules. In closing this chapter, attention should be called to the following rules:

1 Represent each job by a schedule strip cut to the length equal to the amount of the order, divided by the standard hourly production of the work in question.

2 Indicate by green on strip the actual material that is available or anticipated for operation, in terms of the standard hours of work released by the material received.

3 Indicate accomplishments by black line over green, crediting operator or machine at the same rate as charged.

4 Indicate set-up time in yellow.

5 Indicate rejections in red and replacements in pink.

6 Indicate overtime in orange.

7 Have two red plumb lines indicating beginning and end of current day, and move them both to the right one date space each day.

8 Keep strips in constant position while in operation, moving plumb lines only.

9 Use colored sliders or buttons to show irregular conditions.

10 Put strips on boards in order of operation sequence, as far as this is possible.

11 Keep strips posted up to the minute at all times.

12 Keep boards constantly adjusted so that they reflect the true conditions in the shop.

13 Make daily reports of the irregular conditions as shown by signals, with reasons.

14 Show anticipated completion times by red pointer.

Chapter XIX

COÖRDINATING THE ELEMENTS OF GRAPHIC PRODUCTION CONTROL

620 Now that the control board and its mechanism have been so thoroughly described, the task becomes one of using it as the clearing house through which to coördinate the control elements—product, material, equipment and labor. Four things are necessary to consider in this connection:

1 An understanding of the control proposition in its entirety.

2 Analysis of control functions and their relationships.

3 General outline of procedure.

4 Detailed outline of procedure.

621 Figure 98 gives a "bird's-eye view" of Graphic Production Control, and as a concrete illustration of an actual installation will prove of considerable value. The board described covers the use of time cards as strips, with progress slips behind them. This takes care of the first consideration.

622 As to the analysis of control functions and relationships, Figure 99, covering foundry; Figure 100, covering machine shop and foundry, and Figure 101, covering the manufacture of clothing, will illustrate them.

623 Figure 102, covering foundry; Figure 103, covering foundry and machine shop, and Figure 104, covering the making of clothing, will give a general outline of procedure.

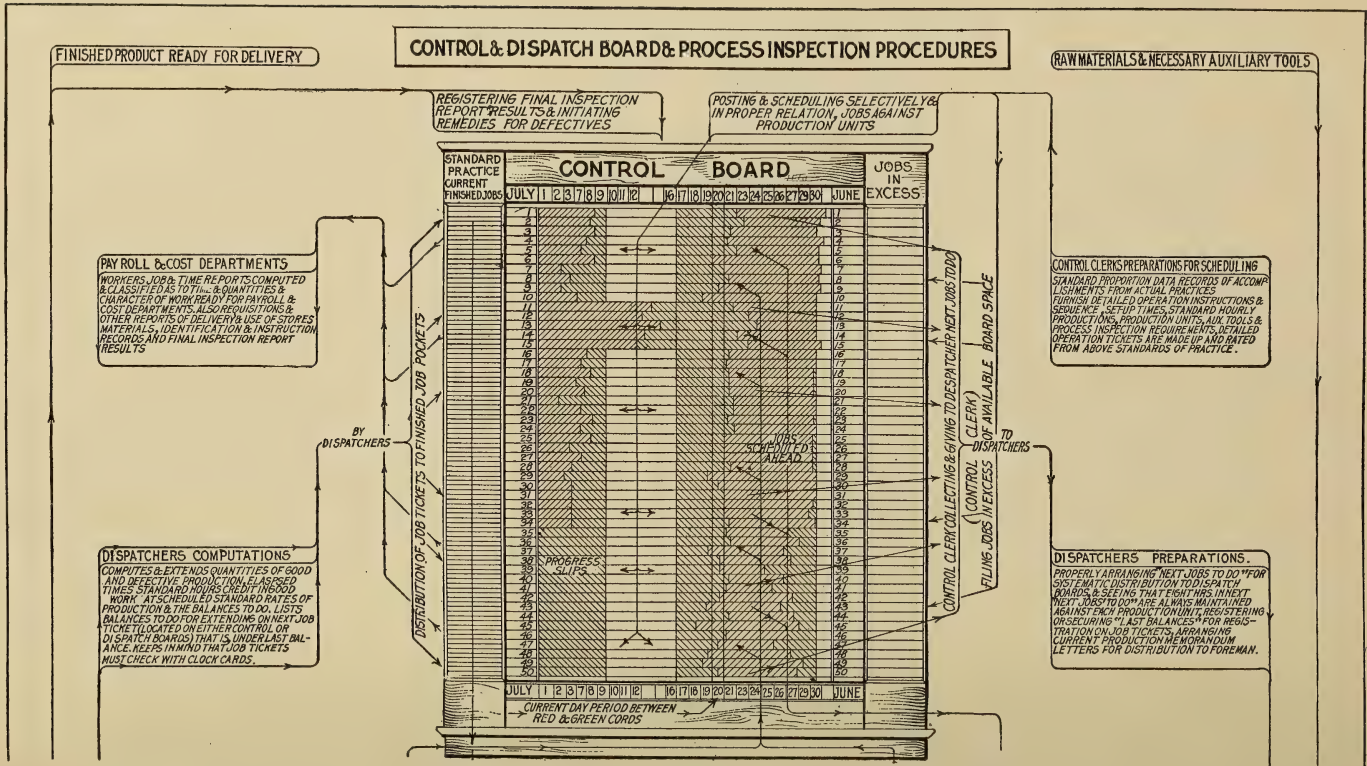
624 The following outlines cover more or less detailed procedures (4), considered under the headings—foundry, rubber factory and machine shops.

625 OPERATION OF CONTROL AND DISPATCH BOARDS IN A FOUNDRY. (See board illustrated at Figure 105.) On issuing shop production orders, estimates from similar work, or actual accomplishments of the past, are used as basis of standard productions per hour. A Workers' Job and Time Report is made up for each operation, and corresponding scheduled or standard hourly productions are registered in *red* on these tickets. In addition, other identifying information, such as order number, working place, department, part number, the operation, quantity on order, number gated together, and metal specifications, are written on each job or operation ticket.

626 Workers' Job and Time Reports, which are made out as above, are sufficient for only one day's work on each operation of order. As a matter of fact, some or all operations may take longer than a one-day period. Accordingly, duplicate operation or job tickets are made up for day (or less than day) periods, which must be applied on each operation of order to complete it. The total scheduled times, of course, are total quantities on order divided by standard hourly productions. Workers' Job and Time Reports never extend from one day period into another, which accounts for the necessity of making out duplicate tickets for each operation for every increment of time applied in any one day.

627 The graphical scale of Workers' Job and Time Reports is used to display extent in hours of schedule. (See Figure 94, Chapter XVIII.) Number of hours scheduled on ticket is indicated by placing a black ink mark at required point on graphical scale. When a required material is on hand, or partially on hand, graphical scales are filled in, in *green,* to the extent which this material represents in available hours' work at standard rates of production.

628 At this point scheduled orders are posted on control boards at locations where there exists available productive capacity. Succeeding operations are scheduled so that there is assurance that material will be on hand from each preceding operation. As material is reported available from finished operations, indication of course is given on graphical scales by filling in with *green,* as has been explained before *on tickets representing later operations.*


CONTROL & DISPATCH BOARD & PROCESS INSPECTION PROCEDURES
FINISHED PRODUCT READY FOR DELIVERY
RAW MATERIALS & NECESSARY AUXILIARY TOOLS
REGISTERING FINAL INSPECTION REPORT RESULTS & INITIATING REMEDIES FOR DEFECTIVES
POSTING & SCHEDULING SELECTIVELY & IN PROPER RELATION, JOBS AGAINST PRODUCTION UNITS
STANDARD PRACTICE CURRENT FINISHED JOBS
CONTROL BOARD
JOBS IN EXCESS
JULY
JUNE
PROGRESS SLIPS
JOBS SCHEDULED AHEAD
CURRENT DAY PERIOD BETWEEN RED & GREEN CORDS
PAY ROLL & COST DEPARTMENTS
WORKERS JOB & TIME REPORTS COMPUTED & CLASSIFIED AS TO TIME & QUANTITIES & CHARACTER OF WORK READY FOR PAYROLL & COST DEPARTMENTS. ALSO REQUISITIONS & OTHER REPORTS OF DELIVERY & USE OF STORES MATERIALS, IDENTIFICATION & INSTRUCTION RECORDS AND FINAL INSPECTION REPORT RESULTS
DISPATCHERS COMPUTATIONS
COMPUTES & EXTENDS QUANTITIES OF GOOD AND DEFECTIVE PRODUCTION, ELAPSED TIMES STANDARD HOURS CREDIT IN GOOD WORK AT SCHEDULED STANDARD RATES OF PRODUCTION & THE BALANCES TO DO. LISTS BALANCES TO DO FOR EXTENDING ON NEXT JOB TICKET (LOCATED ON EITHER CONTROL OR DISPATCH BOARDS) THAT IS, UNDER LAST BALANCE. KEEPS IN MIND THAT JOB TICKETS MUST CHECK WITH CLOCK CARDS.
BY DISPATCHERS
DISTRIBUTION OF JOB TICKETS TO FINISHED JOB POCKETS
CONTROL CLERK COLLECTING & GIVING TO DESPATCHER NEXT JOBS TO DO
FILING JOBS IN EXCESS (CONTROL CLERK) OF AVAILABLE BOARD SPACE
TO DISPATCHERS
CONTROL CLERKS PREPARATIONS FOR SCHEDULING
STANDARD PROPORTION DATA RECORDS OF ACCOMPLISHMENTS FROM ACTUAL PRACTICES FURNISH DETAILED OPERATION INSTRUCTIONS & SEQUENCE, SET-UP TIMES, STANDARD HOURLY PRODUCTIONS, PRODUCTION UNITS, AUX. TOOLS & PROCESS INSPECTION REQUIREMENTS, DETAILED OPERATION TICKETS ARE MADE UP AND RATED FROM ABOVE STANDARDS OF PRACTICE.
DISPATCHERS PREPARATIONS.
PROPERLY ARRANGING "NEXT JOBS TO DO" FOR SYSTEMATIC DISTRIBUTION TO DISPATCH BOARDS, & SEEING THAT EIGHT HRS. IN NEXT "NEXT JOBS TO DO" ARE ALWAYS MAINTAINED AGAINST EACH PRODUCTION UNIT, REGISTERING OR SECURING "LAST BALANCES" FOR REGISTRATION ON JOB TICKETS, ARRANGING CURRENT PRODUCTION MEMORANDUM LETTERS FOR DISTRIBUTION TO FOREMAN.

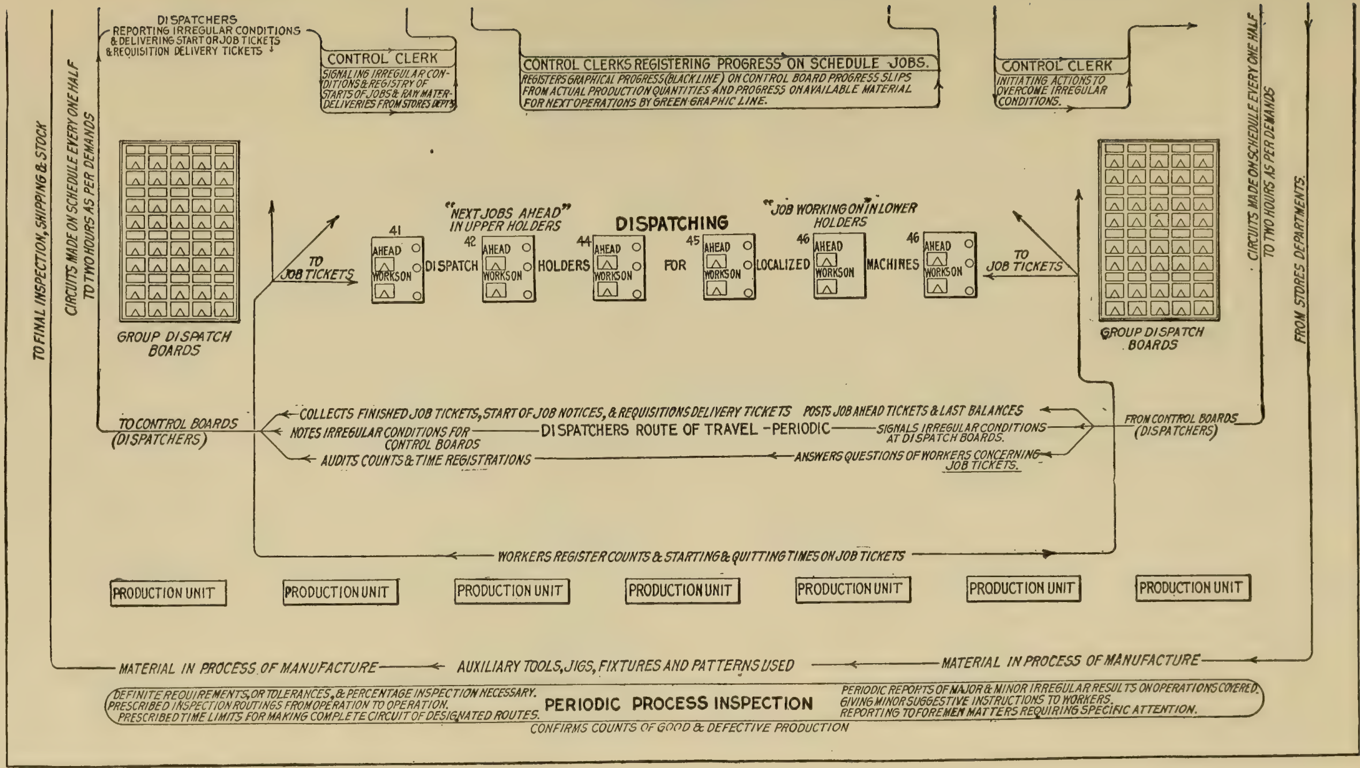


FIGURE 98. CONTROL, DISPATCH AND PROCESS INSPECTION PROCEDURES

629 Workers' Job and Time Reports, in operation of posting in metal pockets of boards, are overlapped so that schedule hours on each ticket are in evidence. The total length of several tickets, posted consecutively, will be a graphical representation of sum total of scheduled hours of

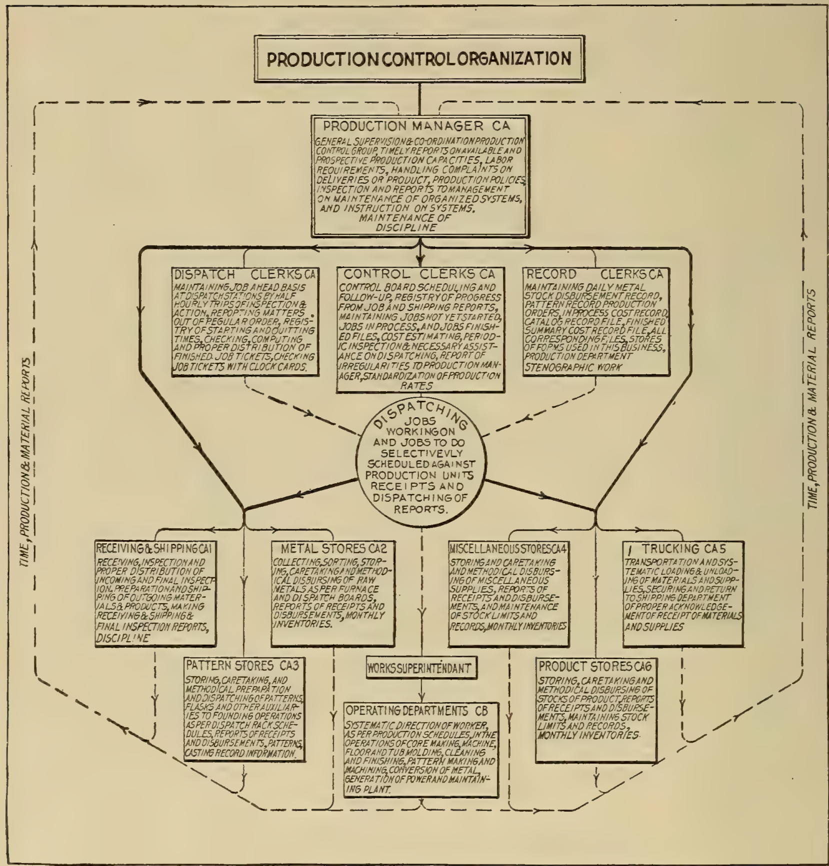


FIGURE 99. FOUNDRY CONTROL ORGANIZATION

above tickets. If they are of one shop order, then you will have on board the sum total of hours scheduled to complete an operation of given shop order.

630 Space is available on board for scheduling 250 hours of work. As you are finishing current month, scheduling of following month's work follows. Excess jobs or schedules

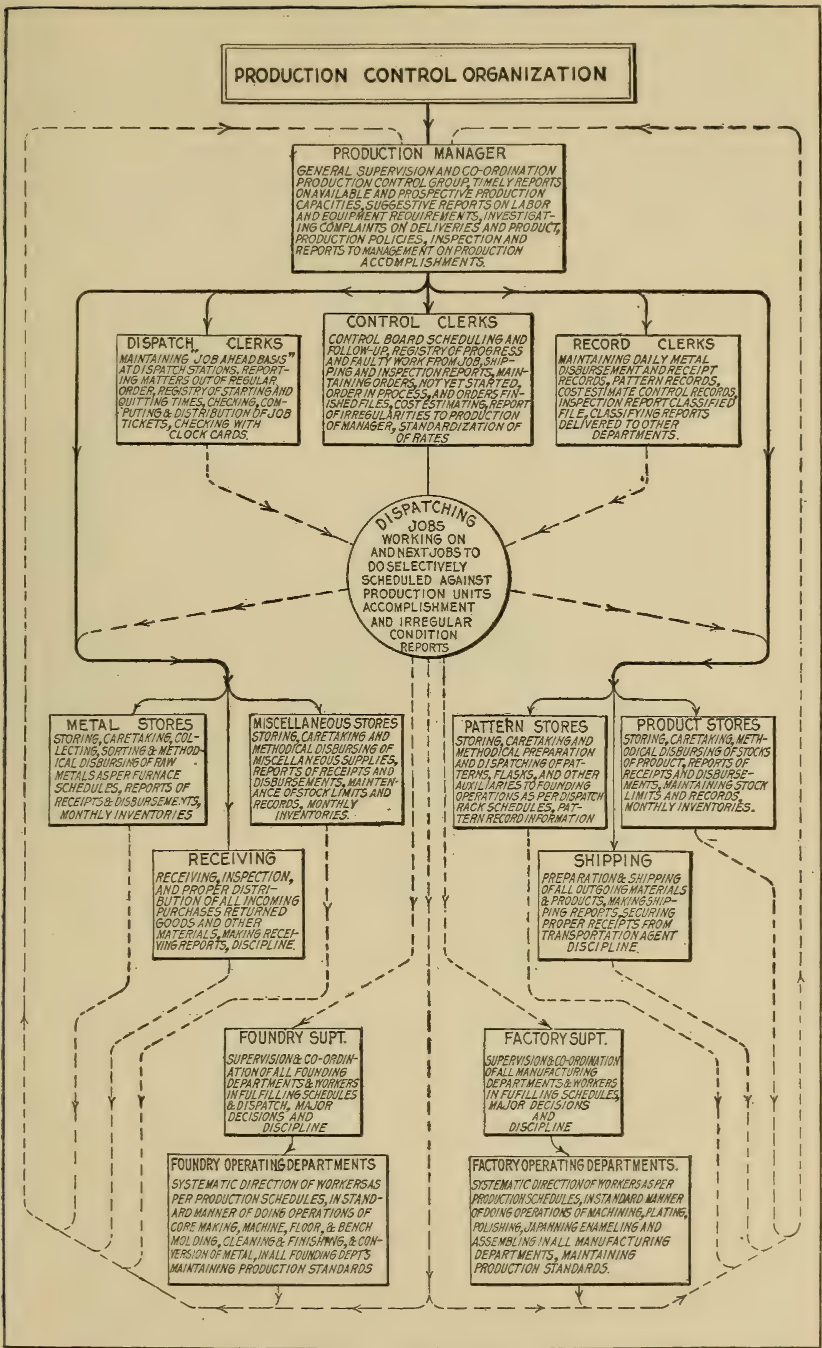


FIGURE 100. FOUNDRY AND MACHINE SHOP CONTROL ORGANIZATION

are temporarily placed in excess job pockets at right-hand side of board. Jobs to be done first are placed in front, and so on in sequence to last job. As space becomes available on graphical scales, these excess tickets are posted in manner explained in foregoing paragraphs.

631 Assuming that all shop orders are scheduled on control boards at the close of each day's operations, a

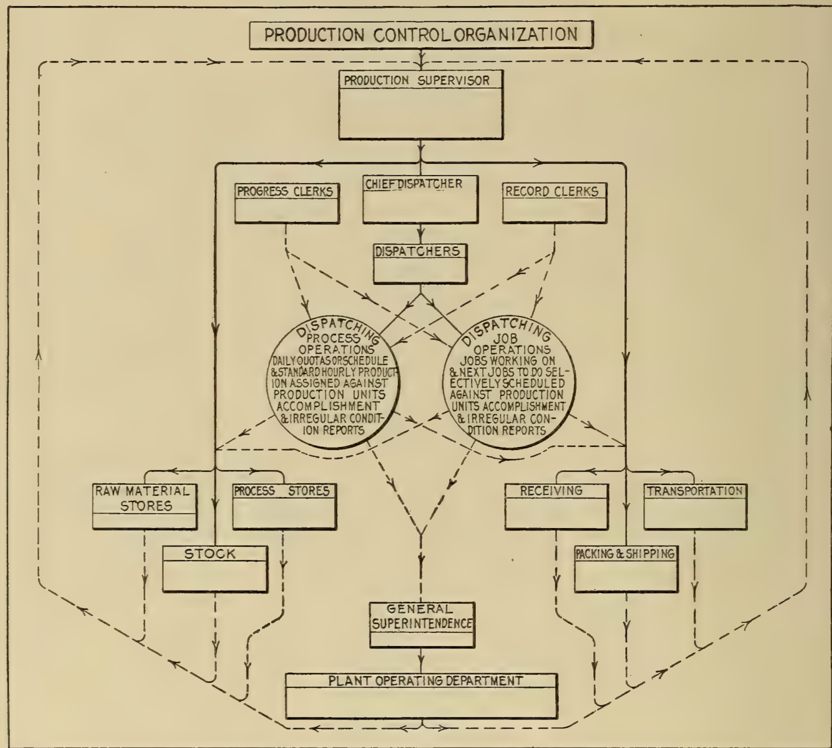


FIGURE 101. CLOTHING SHOP CONTROL ORGANIZATION

number of jobs ahead are taken from board equal to one day's work ahead for all employees. These are posted out in operating departments at places arranged for each production unit on dispatch boards or job holders. As daily work progresses, accomplishments on operations are registered under "Made"; results of secondary operations, such as pouring, are registered under "Secondary Operations," and defective quantities, revealed by process inspection, are placed under "Defective." Process inspectors also

check quantities registered as a result of primary and secondary operations. A suitable place is also arranged on job card for registration of secondary operators' and process inspectors' clock numbers.

632 When a worker finishes a job and starts the next job, he does not rearrange job tickets, for he can easily bend down ticket of finished job and see next job back of it. He

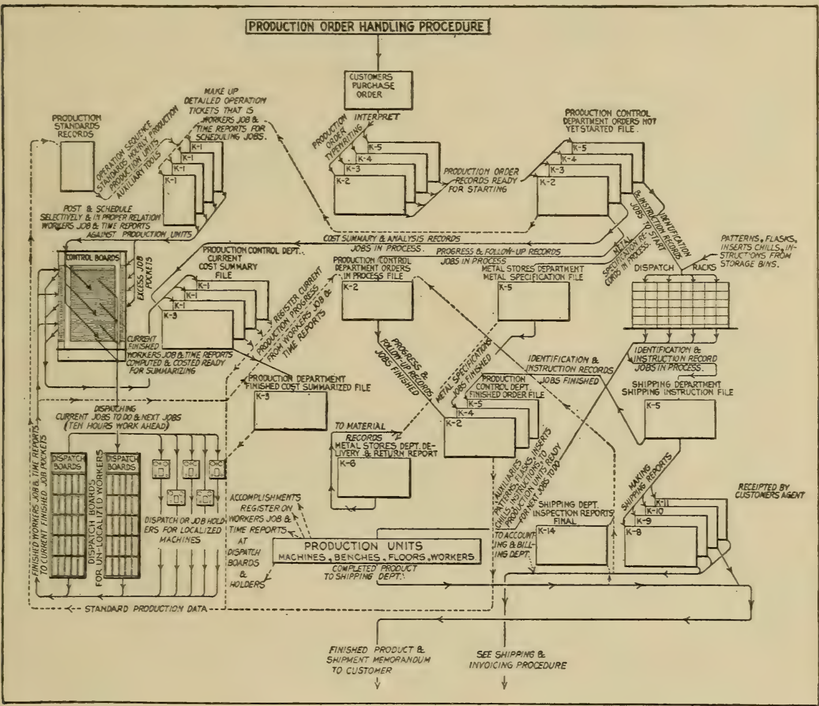


Figure 102. Foundry Control Procedure

does, however, turn around to the front *red side* of tag used for signaling that a job is just finished and he is starting next job.

633 The dispatcher makes rounds of all dispatch boards and job holders every half hour, punches starting and quitting times of jobs just finished and started, makes note of irregularities causing idle-time periods, as well as time lost and especially that workers are following out instructions. He also sees that workers have their identification tags properly displayed on job holders and boards,

that metal and pouring specifications are properly signaled and registrations on Job and Time reports are being carried out properly. He collects Workers' Job and Time

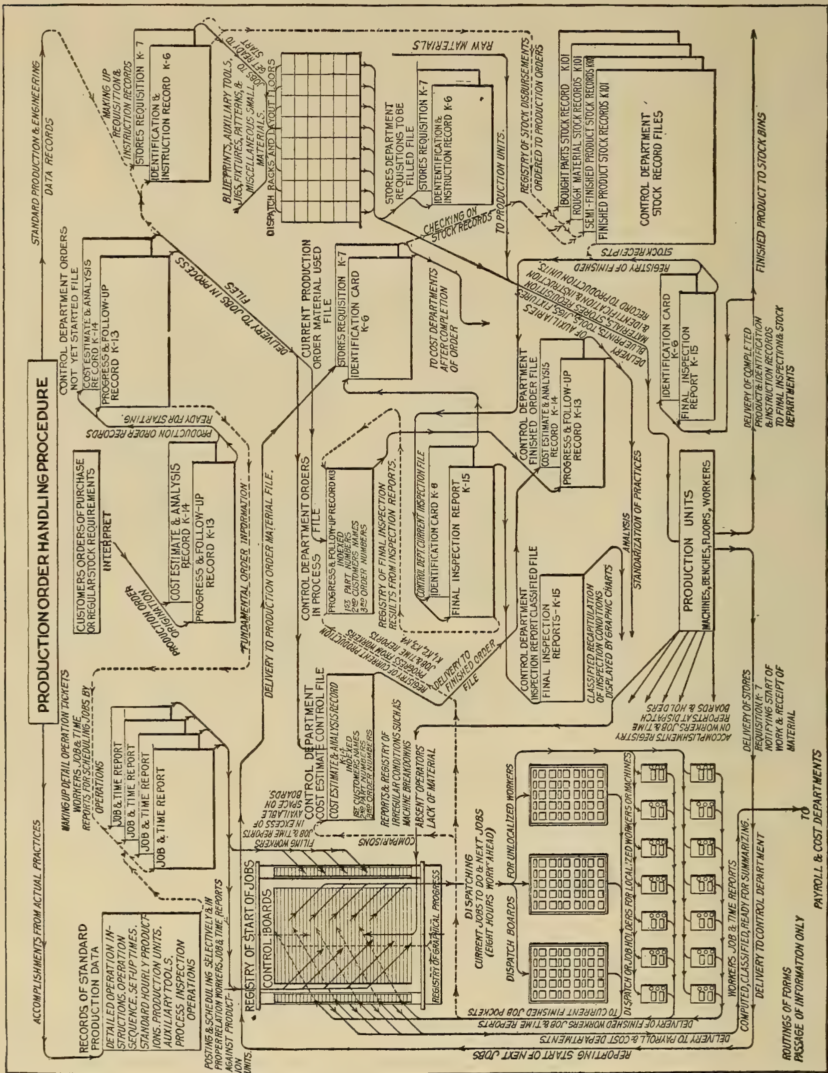


FIGURE 103. FOUNDRY AND MACHINE SHOP CONTROL PROCEDURE

Reports of completely finished jobs and turns around to front *green side* of tag which signals that a job has just been finished.

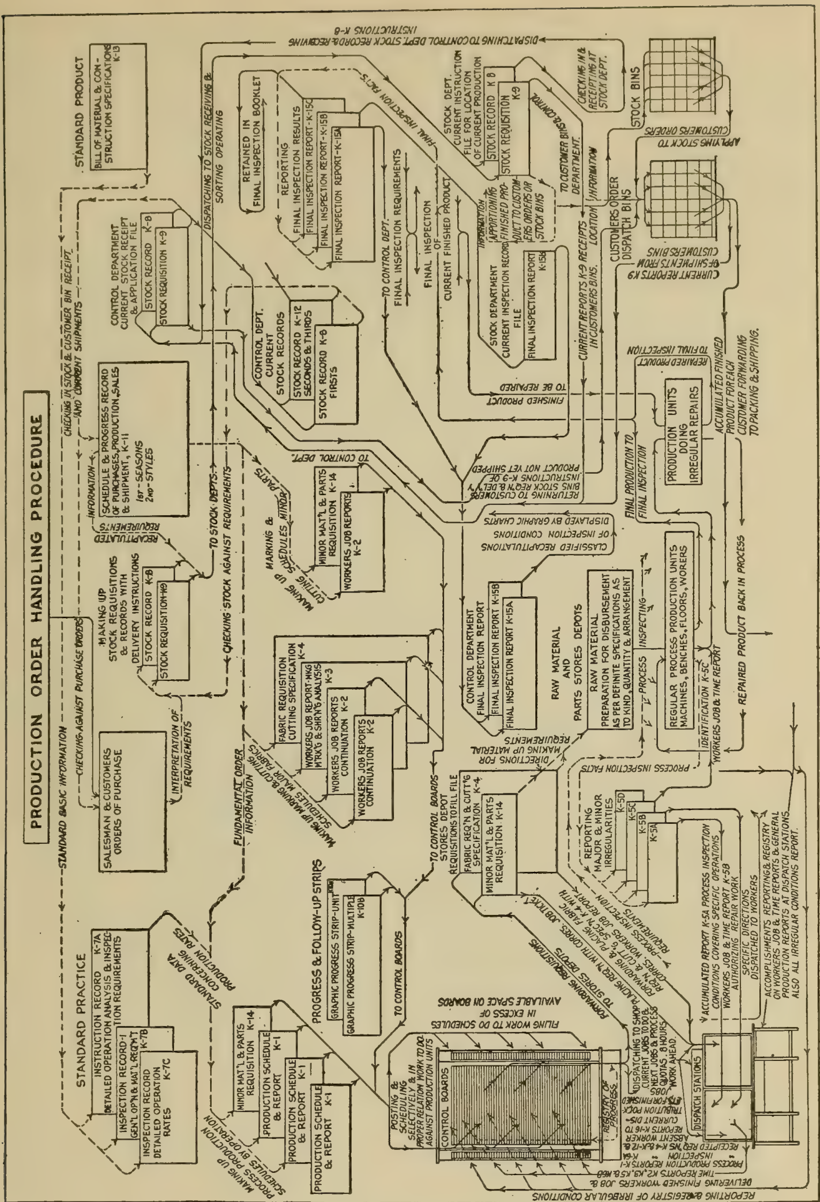


FIGURE 104. CLOTHING SHOP CONTROL PROCEDURE

634 On returning to Control Department, dispatcher files finished job tickets at control board in current finished jobs distribution pockets, along with reports of idle-time periods. They are filed on forward side of partition card,

dividing posted and unposted current finished jobs. All matters not being done as per Control Department instructions are reported to production manager. Dispatcher now makes ready for his next round, taking along with him all rearrangements made in jobs to be done next, or jobs which are to be stopped and others done instead.

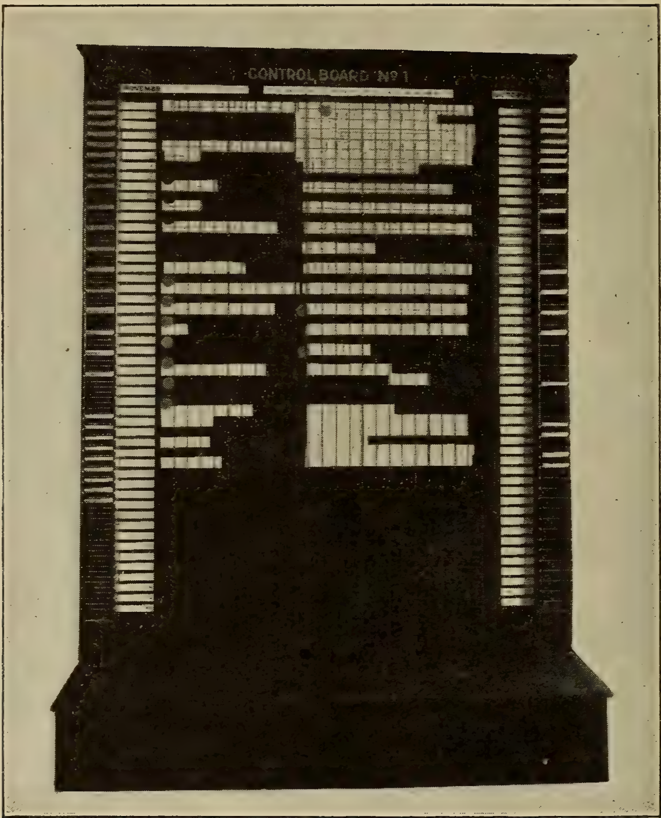


FIGURE 105. FOUNDRY CONTROL BOARD

635 At end of day all jobs of current days are punched out and job tickets for next day or working shift are posted. Where molds of a current day's production have not yet been poured and secondary operations and inspections registered, job tickets are left in place until they are completed. Such uncompleted job tickets are stamped "Yesterday," so that there will be no danger of workers confusing them with current job tickets.

636 Finished Workers' Job and Time Reports of each day's production are first stacked by workers' clock numbers, so that the elapsed times may be checked with clock cards. Where a job has been worked on during *overtime,* it has been previously stamped "Overtime," with signature of person authorizing same, as well as number of hours authorized. In this manner we have control over amount of overtime put in. During this checking extensions of elapsed times are registered on clock cards as well as on job cards.

637 After checking with clock cards, necessary computations are made so as to get total castings made, total defective and total made good, as well as balance to be done. Ordinarily, on molding operations, quantities registered under "Made" and "Secondary operations" are stated in molds, and under "Defective" in unit castings. But the principal thing we are after, in case of molding operations, is the total unit quantity made good.

638 Credit is allowed for molding and pouring operations only in total made good, since it is necessary, at this time, only to make more molds and to melt more metal to replace defectives. Total made good is divided by standard hourly production, giving a certain number of hours' credit to scheduled times, as originally posted on control boards.

639 Registration of credit on graphical scales of job tickets is handled as follows: On supposition that we have received first job and time report of first operation of an order, we will, on graphical scale, mark over green with *black* to number of standard hours' credit. Providing accomplishment was greater than scheduled rate, we fill in our black accomplishment line only to extent of schedule of given job ticket and register surplus on next job ticket. If, on the other hand, amount of work done was less than schedule rate, we fill in black accomplishment line to required amount and must replace ticket on control board so that unfilled scheduled work may be evident and that subsequently we may gradually accomplish and register entire schedule. After a job ticket has been completely filled (that is, filled in, in black), it is taken from control board and placed in distribution pocket for current posted jobs.

640 There is one other matter in connection with control board operations; that is, registration of current day's accomplishments on progress and follow-up records. We register each day (for each casting), from current Workers' Job and Time Reports and Final Inspection Reports, the following:

A Number of molds made.

B Unit quantities of good castings made.

C The accumulated total of good castings.

D The total defective castings reported from molding and final inspection operations, making distinction between the two.

—and from the current shipping reports we register:

A The bill number.

B The unit quantity of castings shipped.

C The accumulated total of castings shipped.

D The weight shipped.

E The accumulated total weight shipped.

641 Castings reported defective from final inspection operations have, it is evident, been formerly credited as good castings during molding operations. We must make a deduction in length of our graphical scales. This is done by filling in with *red* on extra job tickets number of hours required to mold extra castings to make up for defectives. These tickets are placed on boards at end of series of job tickets. This can be done, of course, only if molding operations have not yet been completed.

642 It is the custom in some foundries to consider that a 10 per cent. fluctuation over or under quantity ordered shall constitute fulfilment of customer's order. Circumstances, however, cause different arrangements. Enlargements of order quantities, due to defectives reported in final inspection, are only for the purpose of making as complete a fulfilment as possible.

643 At times of scheduling work on control boards, the following details are looked up with regard to various materials:

A Are they all on hand?

B If not, when will they be on hand?

C From where are they expected?—and references.

D Place for noting time and receipt.

644 All of the above matter is registered on progress and follow-up record mentioned in foregoing paragraph. When follow-up has proceeded to such a point that the internal operating organization of the company can handle it, identification and instruction record, together with pattern record card, is sent to Pattern Department.

645 Pattern and order parts are now located in Pattern Stores, inspected, and prepared in best manner for molding operations, and are then placed on dispatch racks against specific machine, bench or floor or other production unit which requires them. Corresponding identification and instruction record is placed in holder attached to bin, and, with pattern and other parts, it remains there until called for by try-out and set-up man. There are two holders or clips attached to each rack, one holding identification and instruction record of the next job to be done, and the other holding other jobs ahead.

646 After try-out, and when work in process is almost finished, set-up man comes and secures pattern and identification and instruction record and delivers pattern to production unit. If it is a very difficult job, he sets up and starts it, giving any special directions required. He then delivers identification and instruction record to Shipping Department, which there acts as notification that molding operations have been started. In case of coremaking operations, which are always started before molding operations, core boxes are likewise delivered by set-up man, but he does not remove identification and instruction record from dispatch racks.

647 Utilizing first castings on each new job started, the pattern record is checked up. The most important items to check are: number gated together, what patterns they are gated with, weight of each casting cleaned, weight of castings per mold, and gross weight per mold. For costing purposes we must know gate and scrap factors. After pattern record is completely checked, it is returned to pattern record file, located in Control Department.

648 OPERATION OF A CONTROL BOARD IN A RUBBER FACTORY. (See board illustrated in Figure 106.) The planning boards themselves are in all cases record of stocks on hand.

These boards are debited and credited from the various factory reports. At the left of each board is a list of

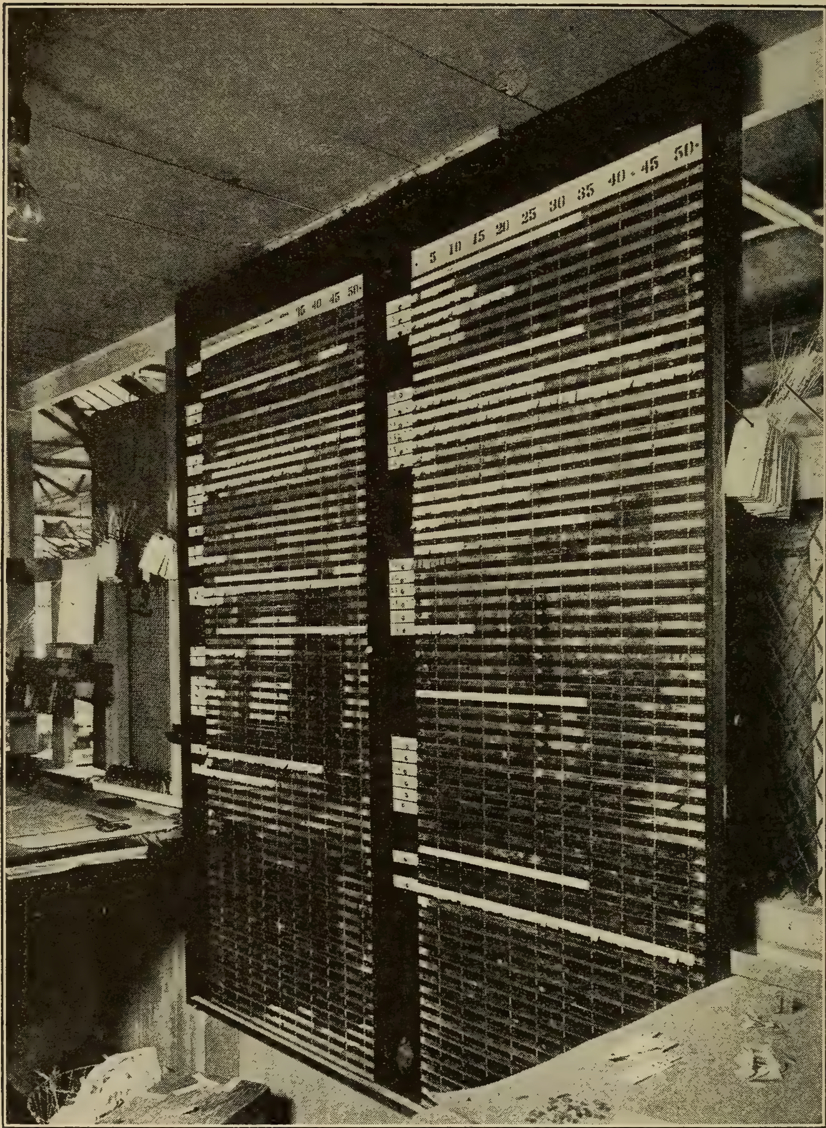


FIGURE 106. RUBBER FACTORY CONTROL BOARD

articles or parts. Opposite each article is a scale divided into the various standards of measure as decided on. Under each such scale is a movable slider. This slider is

moved along the scale as goods are produced or received, and moved back when goods are used, scrapped or withdrawn. The position of the left-hand edge of this slide on the scale, therefore, denotes at all times the amount of this commodity on hand at the date posted. These boards are posted constantly as the reports come in, and are entirely corrected and posted by one man.

649 In connection with the planning boards is a schedule board. This board is divided into the days of the week, and opposite each day, in a space provided, are a number of slips representing the schedules to be issued that day. Tags in red denote master schedules to be issued for use in planning, and those in blue denote schedules that must be issued to factory on that day. These tags are so arranged that schedules go to factory on proper day, so that commodity in question, when produced, will tie in with building schedules and goods will arrive so that work may proceed without delay. At the beginning of each week, in each tag is placed a colored pin, and as each master or factory schedule is made out this pin is withdrawn. This assures the certainty of all schedules being issued, and being issued at the proper time.

650 On this same board is an inventory schedule divided into four weeks of the month. Opposite each week are tags representing the inventories that are to be taken that month. In this way we check our boards on each item each month. These tags are also pinned, and as inventory is taken, boards are checked and pin withdrawn. These inventories are taken in conjunction with inventory clerks employed by Stock Record Department, and call for no extra expense.

651 As an adjunct to planning there is a set of books containing all data as to different parts entering into the manufacture. These data include weight, width, gauge, compound fabric of each piece, arranged in such form as to allow for ready reading in planning. Our issued schedule copies are filed in a special cabinet, and returned completed schedules in labeled books by department.

652 There is also a standard book showing all machine speeds, piece rates, operation speeds, floor space, machines

available, capacity and production by departments, together with various convenient charts for computing planning schedules, as hereinafter explained.

653 Mold books show all core and mold equipment by size. These are debited and credited from receiving re-

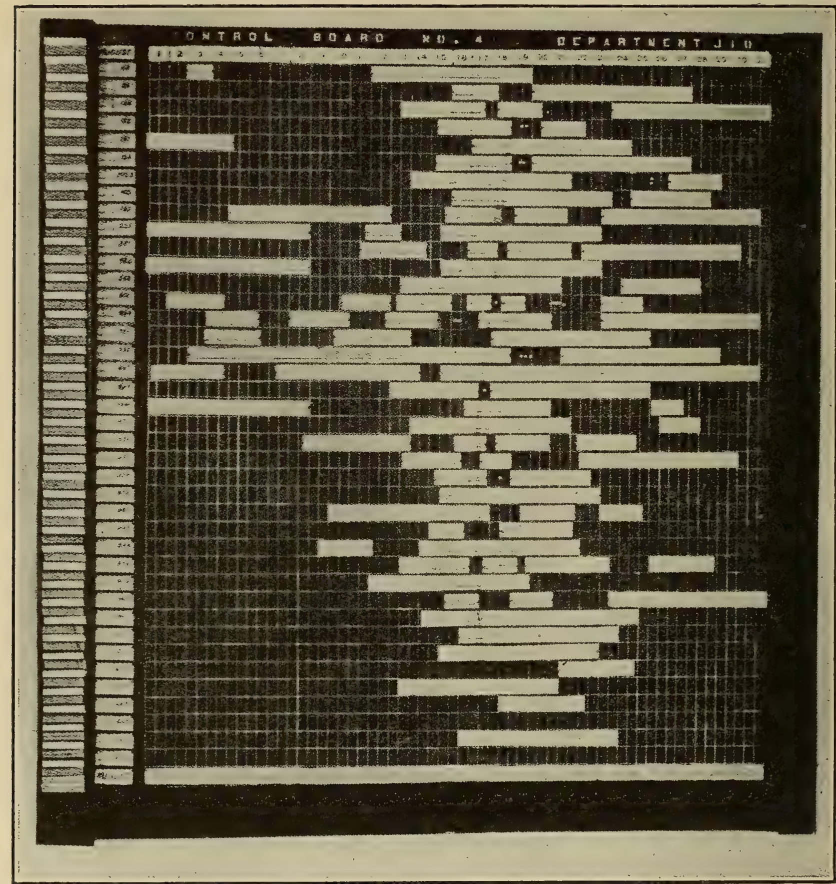


FIGURE 107. MACHINE SHOP SINGLE CONTROL BOARD

ports, and molds withdrawn from service reports, respectively. They at all times show serviceable equipment and are posted daily.

654 OPERATION OF CONTROL BOARDS IN MACHINE SHOPS. (See board illustrated at Figures 107 and 108.)

1 In this endeavor to describe the elements and the functions it should perform, no attempt will be made to

enter into a discussion regarding the theory and advantages of Graphic Production Control.

2 It is sufficient that instructions, clearly defined, be drawn up for reference purposes, and for the purpose of further instruction of those who have not yet come in contact with the actual performance now being carried on in the Control Departments.

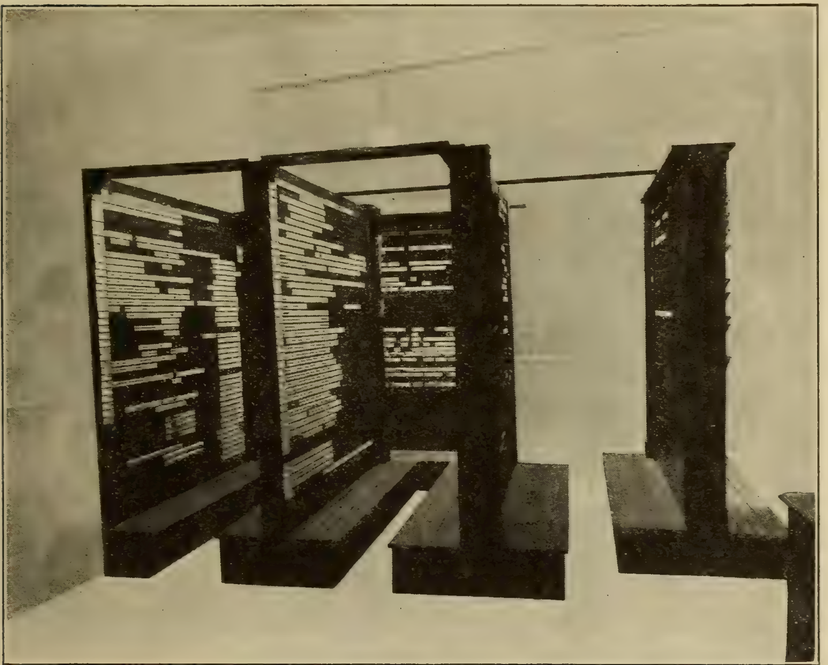


FIGURE 108. GROUP OF MACHINE SHOP CONTROL BOARDS

3 Production Control Departments have been installed in the important divisions. While the basic principles governing all installations are identical, local conditions sometimes make it necessary to vary the procedure for purposes of convenience.

4 Control boards are made of selected white pine, properly seasoned and carefully matched, seven feet square and one inch thick. They should be braced at both ends to prevent warping.

5 The boards are divided vertically by forty-two hori-

zontal sections or slides. These sections consist of two pieces of grooved sheet-metal, designed so that a strip of paper 1½ inches in width will slide easily in the groove.

6 The grooves are 72 inches long. At the left edge a space four inches in width is provided; this space is divided into forty-two pockets five inches deep, one pocket opposite each section or slide.

7 At the right edge is provided a space four inches in width and of the full height, on which, opposite each section, is placed a card 4 inches long by 1½ inches wide. See description at paragraph 25.

8 At the top, a space of two inches is allowed for each calendar day except Sunday and legal holidays. As no production work is performed on these days, no provision is made for their recording.

9 A stout white cord, of a length equal to the height of the board and fastened at each end with a Moore push-pin, serves as an indicator and marker.

10 Signals of colored buttons or flags are provided, the use of which is described later. The boards are placed on a platform raised ten inches above the floor, this for the purpose of allowing the operator, when standing on the floor proper, to reach more conveniently the extreme lower slides. To reach the upper slides the operator stands on the platform.

11 The elements or individual factors used in determining the desired result are as follows:

a Machine Tools—designated by number.
b Bench Space—designated by number.
c Production Order Number.
d Quantity on Order.
e Standard Hourly Rate of Production.
f Operation—designated by machine number.
g Operation—designated by name.
h Kind of Material.
i Name of Part.
j Material Available.
k Date of Starting Order.
l Date of Finishing Order.

(NOTE.—The board above described is one of the earlier types. For later developments of board, see Figures 96 and 97, Chapter XVIII, with accompanying description.)

12 All production orders are issued by the Production Division, under the supervision of the general superintendent.

13 This order, as per Figure 15, Chapter XII, is issued only when the stock ledger cards for raw material show the material to be used on hand. The importance of this fact is demonstrated later.

14 This order form, made out with proper information, is forwarded to the Production Department of the division in which the work is to be performed.

15 On receipt in the Production Department of the division in which the work is to be done, the order is given to the order clerk, who will refer to the Graphic Operation Analysis form, Figure 17, Chapter XII, on which are listed the various operations through which the order will pass.

16 From this form the order clerk will transfer standard operations to reverse side of Production Order. Order clerk will also set down the number of the machine on which each operation is to be performed, and the standard hourly production.

17 This side of the card now becomes a Progress Record. See Figure 21, Chapter XII.

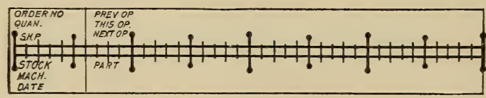
18 The information for routing of order is now complete and information is transferred to an Identification or Move card, which becomes the order that actually goes into the shop. See Figure 34, Chapter XIII.

19 On the same side, as shown, the routing is described by sequential operations.

20 To the Move card is then attached a material requisition (Figure 32, Chapter XIII), calling for the exact amount of material with which the order is to be manufactured. For description of uses for requisition, refer to Chapters XIII and XIV, on Material Control.

21 The order, with the information relating to work to be done and amount of material to be used showing on requisition, is ready to be entered on the control board.

22 Shown herewith is a strip of paper, 1½ inches in width, designed to fit easily in the metal sections or slides as previously described.



23 This strip is divided into spaces of one inch between two parallel lines running longitudinally on the strip, and ⅛ inch apart. As this particular company operates on a ten-hour basis, each one of these small divisions represents one hour, and each group of ten hours, one working day. The longer and heavier vertical lines denote divisions of one day, the lesser lines denote one-half day and the smallest lines one hour.

24 It is now necessary to explain the procedure followed when the Production Order is put on the Manufacturing Schedule.

25 Referring to paragraph 7, it will be noted that the first factor is the number of the machine on which the work is to be done.

26 A form is used on which to tabulate the machine or bench number, the operation number and the type or kind of machine. The position of this form on the right edge of the board is determined by the machine operation. Opposite the machine number, and in the metal strip, is placed the hourly strip.

On the graphic scale or strip is tabulated the following information:

Production Order Number.
Quantity on Order.
Standard Hourly Production.
Kind of Material.
Machine Number.
Date of Starting.
Previous Operation.
This Operation.
Next Operation.
Name of Part.

27 Across the top of the board are spaced, every two inches, the calendar dates. Vertical lines indicate these spaces.

28 In the middle of the date space, or centering the date number, is a Moore push-pin, to which is attached the date string. The string is fastened at the top and bottom of the board, and indicates the current day.

29 As the basis of control for all production orders is the standard hourly rate of production, it is important that the factor be thoroughly understood as to its determination and use.

This factor is that rate at which any individual operation on any piece or pieces should take from start to finish during period of one hour.

Example: A lathe operation will turn a piece of material at the rate of ten pieces per hour. Ten is therefore the standard hourly rate of production.

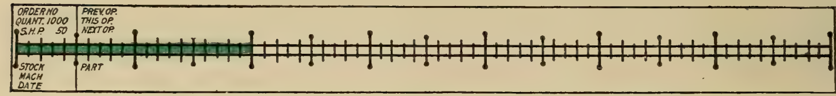
30 During the period when the rate on certain operations was desired,—whether such operation was on a machine or bench,—the time was taken from the moment the operation was started until it was finished. This is only approximate and not absolute. The rate, however, was constantly watched, and corrections were made from time to time, so that those rates now in use are sufficiently correct and dependable.

31 The rate is designated on the hourly strip by the initials S. H. P.

32 The Production Order calls for a certain number of finished pieces, and the requisition furnishes the desired amount of material. When the order is put in process the material will be considered as being consumed at a rate per hour determined by the S. H. P.

33 As the hourly strip is divided into hours, the material is indicated by a green line filled in between the parallel lines, the length depending upon the number of standard hours of work the material received releases.

Example on strip herewith: Order calls for 1000 pieces; S. H. P., 50 per hour; 1000 divided by 50 = 20 hours, or two ten-hour periods; material is on hand, therefore green is shown for 20 hours or 2 days.

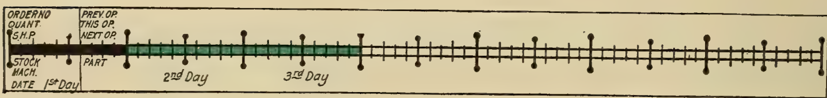


34 The material on hand, and the number of hours through which the order will proceed, having been determined, it is possible to determine the starting and finishing time.

35 The sequential operations being determined and scheduled in the same manner as described above, it becomes necessary to determine the machine on which the work will be done. In case single-purpose machines are used for certain operations, the machine becomes automatically designated. In case of general-purpose machines, the production manager or the superintendent makes the decision.

36 The hourly strip is put in its proper slide opposite the proper machine number, with the extreme left end of the strip under the date for starting. This procedure is repeated for every operation posted on the board.

37 As the work on the machines proceeds, the material shown in green on the strip is consumed. The number of pieces finished is divided by the S. H. P., and the resulting hours of credit are blacked over with pencil and indicates the labor effort.



38 Strip herewith shows material originally for three days but now reduced by one, as one day's work has been finished and posted.

39 The procedure for scheduling and posting having been explained, a detailed description follows, showing actual information given by the control boards.

40 The necessity of supplying material in sufficient quantities with which to meet the full needs of a production order is so important that any deviation from such a plan is an unsafe manufacturing method.

No production order should be issued until the material is at the plant or in such place as to be readily available.

41 One of the virtues of a control board is that it indicates the material or the lack of it, as the case may be. While the control board is not to be looked upon as a stock-keeping record, it is a fact that unless the Stock Record Department keeps a constant and proper supply of material flowing to the machine shop, it will indicate plainly that material in sufficient quantities has not been, or is not being, supplied to meet the requirements indicated on the production order.

42 Therefore it is the duty of the control clerk at all times to keep his material records clear, and, through his dispatch clerk, to keep a constant supervision on the movement of material from operation to operation. This is usually accomplished by complete coöperation between the department foreman, the dispatch clerk and the control clerk.

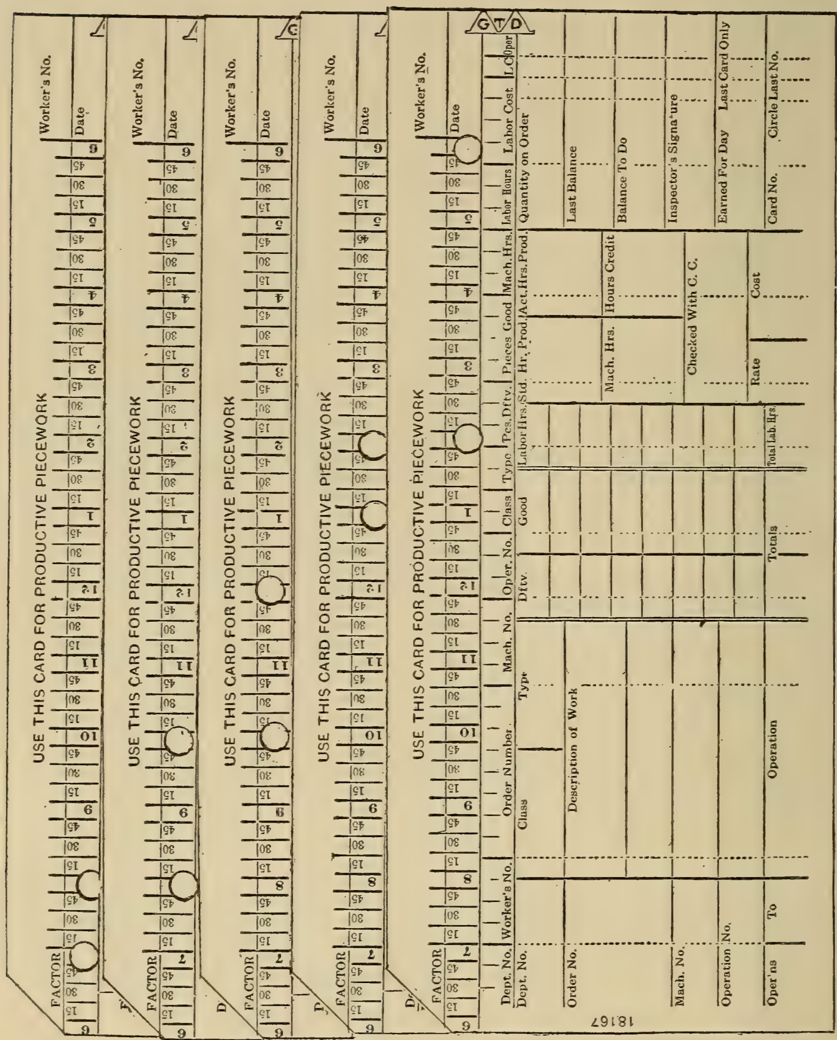
43 When a production order is received, all available information should be secured at once before the control clerk begins to schedule. Information needed is tabulated on the end of each hourly strip, with the exception of the material. This must be computed into hours.

44 Example: On the hourly strip attached, the order calls for 4000 No. 1 studs to be rough turned. The standard hourly rate of production, or S. H. P., is at the rate of 100 pieces per hour; therefore, in one day of 10 hours, 1000 pieces, 100 times 10, would be carried through the day.

45 It would, therefore, take four days at the rate of 1000 per day to complete the order for this operation.

Material, indicated by the green crayon, should then be filled in on the strip for four days of 10 hours each, or 40 hours.

46 As the material is used, the green is blacked over. The strip indicates that work to the amount of two days



of 10 hours each has been posted, and that one-half of the material, or 2000 pieces, has been used.

47 The information for posting the strip is taken from the workers' time card. See Chapter XVI for information as to time cards.

48 The information as regards labor hours and number of pieces made, good and bad, is the only data in which the control clerk is interested.

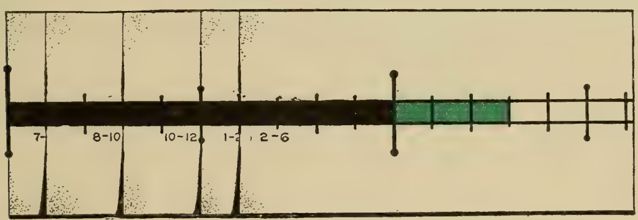
49 The above card applies only to an order which has been in process during a 10-hour period without interruption.

50 As this condition does not always prevail, it is shown here how to control several different orders which have been in process on the same machine during the same day for 10 hours. In this example five different orders are used.

51 As shown on the time card below, the first order was started at—

			Hours	Pieces
First	7 o'clock;	finished at	8–1	500
Second	8 o'clock;	finished at	10–2	500
Third	10 o'clock;	finished at	12–2	100
Fourth	1 o'clock;	finished at	2–1	25
Fifth	2 o'clock;	finished at	6–4	100

52 The hourly strips are accordingly cut for the hours shown for each order on time cards. The five orders are separately listed, one for each strip, and the day's work shown as below.



53 It will be noted that on the last order there remains unused material sufficient for three hours' work, or 75 pieces available for the machine operation during the next working period.

54 Overtime being a common occurrence,—and by overtime is meant only such as used by a worker after the regular hours, or who simply carries on his work over a longer period in one day than is ordinarily the case,—provision must be made for the posting of such effort.

55 To show this condition on the control board, over-

time is posted on the board in orange. See Figure 87, Chapter XVIII.

56 To make proper postings covering night work or extra shifts, see Figure 90, Chapter XVIII.

57 The tabulation of the amount of material for each operation is based on the theory that until the first operation is complete and all pieces have been through that operation, there is no material available for the next or second operation.

58 In actual practice, the material is moved from operation in lots equal to a certain labor effort over a specified number of hours. The twelfth law of Graphic Production Control covers this point.

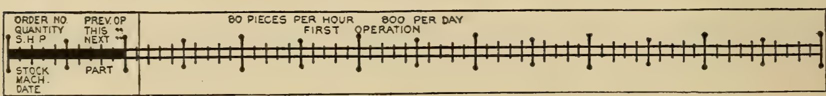
59 These lots may be as large or small as the production manager decides. For instance, he may decide that the work performed in one hour on the first operation supplies sufficient material to start the next operation; or this period may be a day or any other period of time, and so on through the several operations.

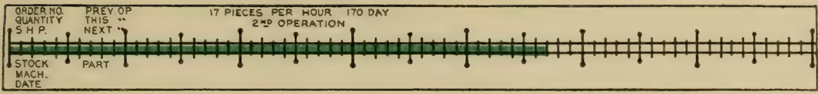
60 On the control board the material posted for each successive operation is determined by the standard hourly production rate on the operation about to be done. To make this clear, an example is given:

61 There are 800 pieces to be done, the standard rate for the first operation being 80 per hour. Standard rate for second operation is 17 per hour, or 170 per day. Therefore the available material for the operation will cover a period of 47 and a fraction hours, or 800 divided by 17.

62 The second operation being slower than the first, the material will accordingly last longer; 800 being one day's work on first operation, with the same amount being approximately five days' work on the second operation.

63 As shown on the hourly strips attached, 800 pieces passed through the first operation, Strip A, and provided material for nearly five days, as shown on Strip B.





64 Should the next or third operation be at the rate of 100 pieces per hour, material for 8 hours would be shown.

65 Note that the second operation, being the slowest, controls the speed of production on the entire order.

66 Since work is interrupted on the machine or bench by various causes, signals have been devised which graphically call attention to such interruptions. See Figure 13, Chapter XI.

67 The moment a machine becomes idle, one of these signals must be posted on the board, indicating by color the reason for idleness, and by placement the hour at which the machine stopped.

68 It is the duty of the dispatch clerk to notify immediately the control clerk the moment any order in process is stopped for any reason. The control clerk then posts such signals as are necessary.

69 Further instructions as to control methods as regards clerical entries will be found in Chapter XVI.

70 See Chapter XII on Product Control; Chapters XIII and XIV on Material Control, and Chapter XV on Equipment.

Chapter XX

THE USE OF THE CONTROL MECHANISM IN PLANNING

655 Work can be dispatched after it has been scheduled to machines and working places; but to schedule work, it must first be planned. Hence the importance of a chapter on this matter of using our control mechanisms in this important and difficult task.

656 There are four elements which always enter into the matter of planning work ahead:

A Date work is wanted, or promised, or should be ready.

B Time work will take in the plant.

C Available capacity in plant, or, to put it another way, time taken by other work already planned and scheduled.

D Unforeseen contingencies, like failure to get materials, breakdowns, uncertainty as to labor and the like.

657 The first element—date wanted—is in most cases a known factor, and, other things being equal, is generally known sufficiently in advance to permit of proper planning.

658 Reference to Figure 17, Chapter XII, "graphic operation analysis," will show that the best flow of work as to sequence of operations with all machines available is a matter of record. This same kind of chart can be worked up for sub-assembly and erection operations. The matter of assembling all these data in one place is therefore important, in that it gives us a manufacturing ideal—something to shoot at, which in industry is superior to aiming at nothing.

659 Figure 109 (which is Figure 3, Chapter VI, repro-

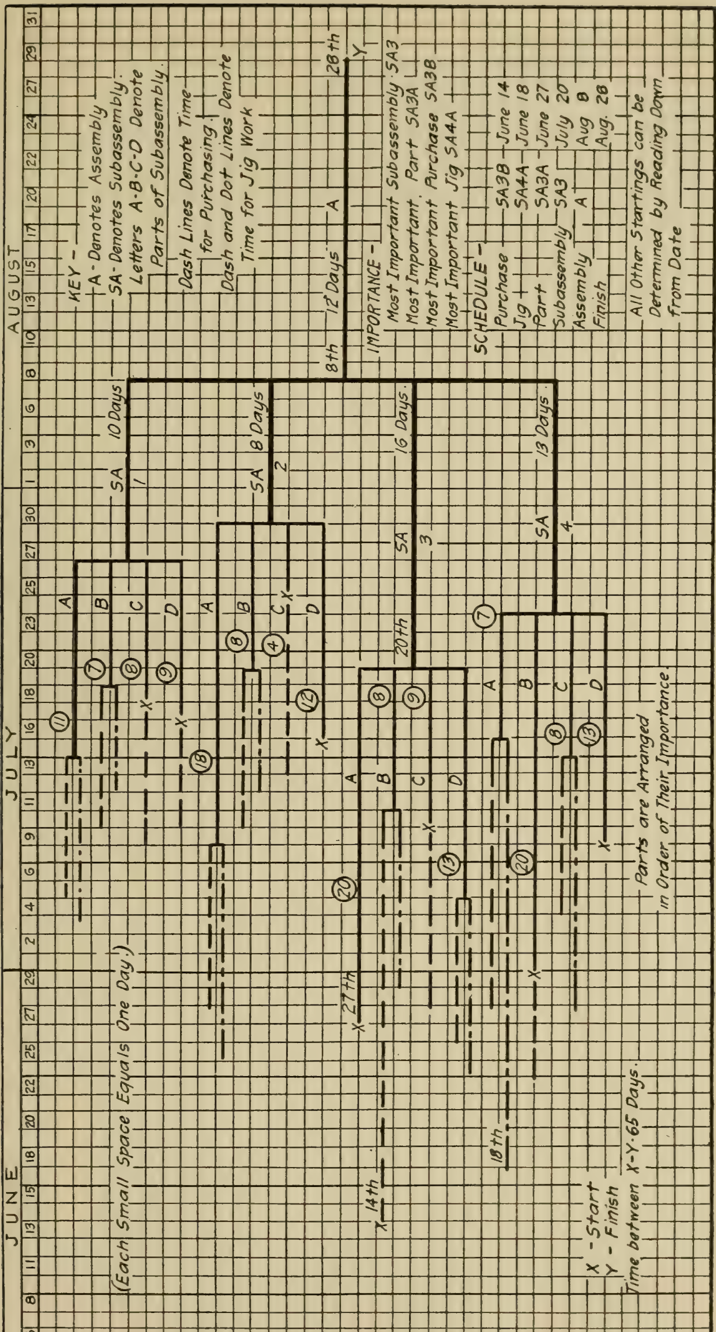


FIGURE 109. THE IDEAL MANUFACTURING SCHEDULE

duced for convenience in studying this chapter) is a synthetic diagram of all the available data as contained in "graphic operation analysis" and other records. We note that the order in question was received June 3 and is wanted August 28. Thanks to the law of "Draw *vs.* Push," we can work back from this known quantity (time wanted), and from our operation flow diagrams, and data establish starting and finishing points. As will be seen from chart, reading down from dates, we have the theoretical starting time of jig work, purchasing, machining, sub-assembly and erection.

660 If no other work were in the shop, this chapter could end right here, but we must face practical conditions and take into consideration the hundreds of other operations that must not be interfered with, unless with the best of reasons; nor must we fail to do everything to finish the work in question by August 28.

661 In proceeding to schedule this job, we must therefore consider three things:

A Stock on hand in raw, semi-finished and finished materials.

B Conditions of our machines and working spaces as to available capacity.

C Condition of our assembly working places as to available capacity.

662 The matter of materials in stock should be taken up first, and reference to our stock records, Figures 29 and 30, Chapter XIII, will determine what will have to be made. We should next answer these questions:

Can we make purchase of SA3B on June 14?
Can we start jig work on SA4A on June 18?
Can we start machining of SA3A on June 27?
How about benches for starting assembly of SA3 on July 20?

663 Knowing our material on hand and what will have to be made, and being able to answer the above questions, we have a fair sort of a start toward planning.

664 We should now analyze the work of machining and

assembly being done *on other orders,* as a basis for determining what machining we can start on this order, and what assembly work we can take up at the same time. Knowing the operations to be performed and the equipment designated to do them, a study of the control boards covering the machining operations is the next thing to take up, *keeping in mind the starting times covering sub-assembly; for while we are working from X toward Y, we must not overlook the great importance of going back from Y toward X.*

665 The control boards will show what is being worked on and what is to follow. Congestion is shown by no gaps or no empty spaces in the strip pockets on the boards, the opposite condition indicating idleness or anticipated idleness. Further, there is the possibility that other work may be displaced if sufficient margin exists. We can therefore tentatively schedule the machining operations, which, with what finished parts we have on hand, will serve as a basis of going back from Y. This we can do by analyzing the work in process ahead of assembly and erection benches, from all of which we can tentatively schedule this phase of the manufacturing.

666 As can be seen, comparison of these two tentative schedules will determine whether or not they fit together. If not, other plans will have to be made. If they do, then these tentative schedules can become our planning, and routing and scheduling can be arranged for accordingly.

667 I am presupposing, of course, that there are control boards covering assembly and erection benches and working spaces, and that between them and the boards covering the machining operations there is coördination of material of the proper kind, and an organization looking after both sets of boards.

668 This leads to the logical question—What is the plan of control boards covering assembly and erection work, and what is proper material coördination? Let us take up the matter of boards first and make what may seem a rather startling statement—*control boards for assembly and erection are the same as those covering machines.*

669 Reference to Figure 110 illustrates a machining strip on which appears the sub-assembly, index B2. What is

there to prevent our using a single strip covering sub-assembly B2, and placing it on an assembly control board, opposite the bench or floor that will do the work, locating the strip under the proper starting and finishing dates, and then treating it in exactly the same manner as the machining strip, from the standpoint of entries of material (green), accomplishment (black), defectives (red), and overtime (orange)?

670 You may say, "Yes, your argument is sound as it applies to machining, for in machining you are dealing with only one piece and operation at a time, but in covering

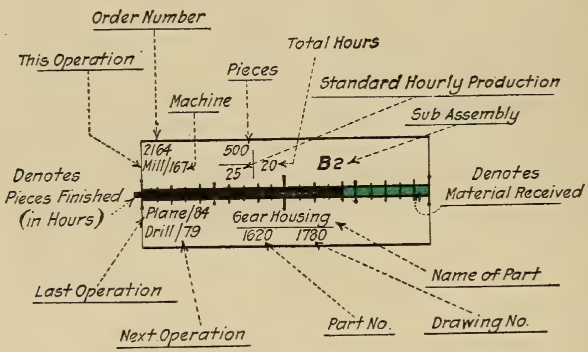


FIGURE 110. MACHINING STRIP SHOWING SUB-ASSEMBLY B2

an assembly operation with a single strip, you are dealing with several parts and operations."

671 Let us analyze this particular angle. Whether a sub-assembly has 10 or 100 pieces, the one part which needs to be watched most *is that which has the longest cumulative operation times, or the one which is the slowest-moving part.* There is also the fastest-moving part to consider, for this is oftentimes overlooked because of the shortness of the operations. It becomes lost in the shuffle and is forgotten until needed. Between these two extremes, which are generally constant, there is the element of shortages to take into account at times. The slow-moving and fast-moving and delayed parts are the real elements to consider, regardless of the number of parts entering into a sub-assembly.

672 Hence the strip can be designed to cover the slowest-moving part, as this limits absolutely what can be assembled; for the speed of work is entirely dependent upon the travel of this part through the machines. For convenience, the fast-moving part should be kept in mind to insure its not being overlooked, nor should we fail to consider shortages. In Figure 111 is illustrated a form of strip designed to cover assembly work, with reference to the factors above outlined, and this will be found self-explanatory.

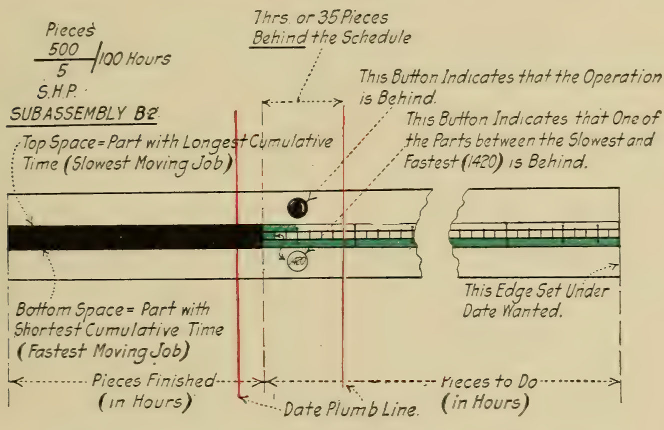


FIGURE 111. ASSEMBLY STRIP PROVIDED WITH THREE PLACES

673 The matter of work falling behind in the machining, and cases of this kind, should be, and generally are, the exceptions, as it reflects on the operations of assembly work, being simply a matter of proper coördination between the machining and assembly divisions. As previously pointed out, work behind in machining is signaled with a black button or slider. The machine strip shows the assembly index number. It is not a difficult task to transfer this information to the assembly boards, as indicated in Figure 111, by white button showing that part 1420 is behind at the machines. It is simply a case of playing machine boards against assembly boards, *as both are parts of the same mechanism.* If there are no black buttons on the machine boards, and the slow-moving parts are being watched, it is

obvious that work will flow to the assembly operations in proper order and on time, consequently there is nothing to be concerned about.

674 The above procedure is of the greatest value in cases where there is a fairly uniform flow of parts from machines to assembly operations. Where parts are made for stock, for repair orders and for assembly and erection, all at the same time and in the same shops, then a coördinating mechanism must be interposed between machining and assembly boards which will reconcile the differences in the flow of materials. We must, in other words, create a stopping-point after our machining operations, rearrange our information and then plan out the assembly and erection.

675 This coördinating mechanism was briefly described, as far as the principle is concerned, in Figure 7, Chapter XI, and is further elaborated upon in Figure 112, here illustrated,—"graphic inventory of material for assembly." Name of assembly and its index number are at top of sheet. The name of part, item number, part number, pieces per unit and location are shown in proper columns. Entries are made according to the number of units the material will make, *and not the pieces per part,* which are variable quantities. Each small square may equal 1, 2, 5, or 10 units.

676 What we desire to keep track of, with reference to assembly material, are the following:

A Desired assemblies, shown by light dotted line.

B Assemblies ordered in process, shown by light blue vertical line.

C Assemblies finished, shown by heavy black vertical line.

D Total requirements, shown by heavy red vertical line.

677 The chart shows that because we had parts enough we issued production orders for 8 on 3/24, order 1675 (finished), and 14 on 4/6, order 1815 (in process), or 22 in all as indicated. We want to order 15 for order 1620, but cannot, as we are in need of parts for four units on item 6. The next job following 1620 needs parts for units on items 3, 6, 7, 10, 11, 14 and 15. The total requirements are 85 units.

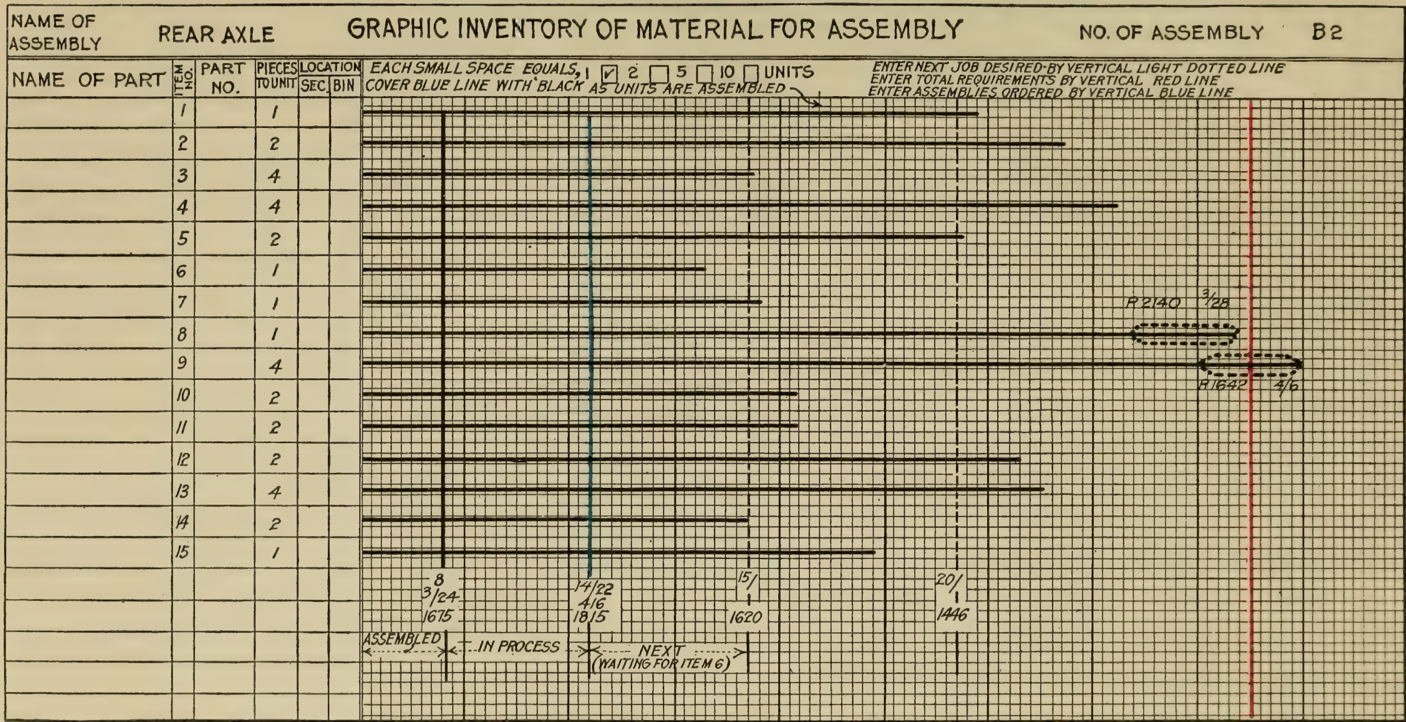


Figure 112. Graphic Inventory of Material Ready for Assembly

The dotted circles (representing an erasure on the form) at the end of lines for items 8 and 9 are deductions on account of excess supply of these materials, and are for repair orders R2140 and R1642.

678 Quantities can be progressively accumulated, so that the record can be used constantly and show at all times the real condition of material for assembly, through the use of split sheets, or the sheets can be built up on the plan of the accordion. If desired, sheets can be made out according to orders and material apportioned to the most important jobs, transfers being shown by erasing ends of lines on one sheet, corresponding to the material deducted, and adding to the proper lines on the sheet covering the assembly getting the material. In the figure here illustrated, all orders for the same assembly are on the one sheet.

679 As the record shows what is on hand and in process, as well as what has been used, it makes an excellent graphic inventory for use as a coördinating medium between machining and assembly control boards. As production orders are issued for assemblies,—*and they are not issued until there is sufficient material on hand,*—strips are made out for the assembly control boards, and arranged in accordance with the planning, from which point the dispatching of work and the posting of the boards are handled in the same manner as for the machining control boards.

680 Given this graphic inventory record, along with the records of raw and finished materials, progress records covering operations of parts and sub-assemblies, the manufacturing schedule, and the machining and assembly control boards, we have all the elements necessary with which to make plans that will result in efficient scheduling and dispatching. If work falls behind at the machines, the assembly boards are marked up accordingly; as short balance lines are noticed on the graphic material inventory, the machine boards are studied to determine where pressure can be exerted to speed up the parts in question; if assembly benches or floors are ahead of their schedules, machine boards can be studied to determine whether progress can be made to keep up with the faster pace of the assembling. At any rate, all the essentials necessary to

efficient manipulation of machining and assembly boards and auxiliary mechanisms are at hand and it only remains to use them properly.

681 In this connection, it should be stated that final erection can be controlled in the same manner as sub-assembly work, through the use of control boards covering erection. The flow would be: machine boards, to graphic inventory, to assembly boards, to graphic inventory, to erection boards.

682 The whole proposition is a double-entry affair all the way through. As material is received, "Stores" is charged and "Cash or Accounts Payable" is credited. As material is delivered to first operation, "Stores" is credited and the operation strip is charged in green in terms of the standard hourly production for the first operation. As labor is performed, the strip for the first operation is credited in black in terms of its standard hourly production, and the strip for the second operation is charged in green with the material finished in terms of the second operation's standard hourly production. This is done until the last operation is reached and the labor is performed on it, the strip is credited in black for its standard hourly production *and the sub-assembly strip charged in green for the work completed in terms of the standard hourly production for the sub-assembly operation.* As sub-assemblies are finished, the strips are credited in black at their standard hourly production rate, and the final assembly strip charged in green at the standard hourly production rate of final assembly, which is credited in black as work is finished, the finished product being charged.

683 The Use of Control Mechanisms in Planning. In the fourth chapter, "Graphic Control in Industry," paragraph 101, an outline was given showing fifty things that the methods could be expected to indicate to the practical shop man. To aid in a synthetic study of the entire subject, and to answer the "how" as it applies to these points, it was decided to list them one by one, with references to chapter and figure numbers, to facilitate the study, as follows:

684 Relative Importance of the Various Parts of an

Order from the Standpoint of Purchasing, Processing and Assembly. Reference to the sixth law of Graphic Production Control, paragraph 137, will outline the general theory regarding this. Figure 3, Chapter VI, and Figure 109, Chapter XX, show the practical application of this law. This chapter should be read in connection therewith.

685 Pieces Received from the Outside or from the Foundry; Pieces Processed According to Part of Operation and the Units Assembled at Any Given Time. Figures 38 and 39, Chapter XIV, which should be reviewed in connection herewith, illustrate Material Control Sheets,

OVERTIME AND NIGHT WORK

TO CONTROL DEPARTMENT IN ORDER TO MAINTAIN
SCHEDULE OF ORDER ________
PART ________________ OPERATION ________________
IN ________________ DEPT., IT WILL BE NECESSARY FOR

MAN NO		TO WORK	ALL NIGHT	
MACHINE NO.				
GANG NO.			HRS OT.	

FOR THE FOLLOWING DATES ________________

SIGNED	APPROVED BY

Figure 113. Form for Overtime and Night Work

one on the principle of colors and the other by areas, which in graphic form cover the flow of work from ordering to assembly. The methods described in Chapters XVIII, XIX and XX will also indicate how well this work is covered.

686 Estimated Times of the Various Operations; Actual Times against Estimates (Progressive) and the Gains or Losses in Actual Times over Estimated Times. The Progress Records, Figures 21 and 22, and the "anglegraph," Figure 20, all in Chapter XII, will illustrate how these times are watched. Estimated times are entered, and as time is reported it is deducted from the estimated times, the balance covering the time still to be spent on the work.

687 The Cost of Operations as the Work Progresses. As previously mentioned in this discussion, the real pro-

ductive investment is *time*. It is time which is purchased, whether in the form of hours of workmen or of the time of the people in other plants, expressed in the form of material. The bricks in a plant and the machinery erected therein represent time in making them. If, therefore, we know what time should be taken on a given piece of work and know what time *is being taken,* whether on the part of direct or indirect workers, through knowledge of average material and labor costs and predetermined overhead rates, we have an excellent way of determining what cost is before and during work, as well as after work is performed. Reference to Figures 20, 21 and 22, Chapter XII, and a study of the Control Board strips, Figure 12, Chapter XI, and Figures 89 and 93, Chapter XVIII, will show how this time factor can be watched. Review Chapter XXV, on Costs, in connection herewith.

688 Relation at any Time between the Actual Progress of an Order, in Whole or in Part, and the Normal Progress, Indicating How Far the Actual Progress is Ahead of, or Behind, the Normal Progress. In this, use can be made of the "anglegraph," Figure 20, Chapter XII, to decided advantage. Also Figure 40, Chapter XIV. Normal progress is also shown by length of strips, and the actual time by relation of black, representing labor effort, to the date plumb line for end of current day. See Figure 12, Chapter XI, and Figures 89 and 93, Chapter XVIII.

689 Apportioning Work to be Done Against Equipment or Departments, in Such a Way as to Show Congestion or Excess Capacity. Reference to the different cuts of control boards (Figure 11, Chapter XI; Figures 105, 106, 107 and 108, Chapter XIX) will show that idleness and excess capacity are represented by absence of white strips or gaps between strips, while congestion is shown by machines always showing white, with other work to follow. See also Planning Sheet, Figure 115, Chapter XXI, with respect to this feature of congestion and excess capacity. If equipment is going to be idle, you will know it in advance. If equipment is going to be overworked, you will also know it in advance.

690 Performances of Machines or Operations Against

Estimated Productions, Showing Gains or Losses. This is shown by relation of black, representing labor effort, to the date plumb line covering end of current day. See Figure 12, Chapter XI, and Figures 89 and 93, Chapter XVIII.

691 Following Up Purchases. Figures 26, 27, 28, 29 and 35, Chapter XIII, and Figures 38, 39 and 40, Chapter XIV, will facilitate study as to this.

692 Continuous Inventory of Material. Figures 29, 30 and 31, Chapter XIII, cover this.

693 Inventory of Labor, in Hours, Against Machines and Operations. In Material Control, stock accounts are charged with receipts and credited with disbursements, the differences showing balances on hand. In Labor Control, we charge strips in green for material received and credit them for work done in black, the differences between black and length of strips indicating work still to do, according to machines and working places. See Figure 12, Chapter XI, and Figures 89 and 93, Chapter XVIII. This work still to do will cover three conditions:

A Hours of work for which no material is available or anticipated, as shown by white space.

B Hours of work for which material is anticipated, shown by light or wavy green line.

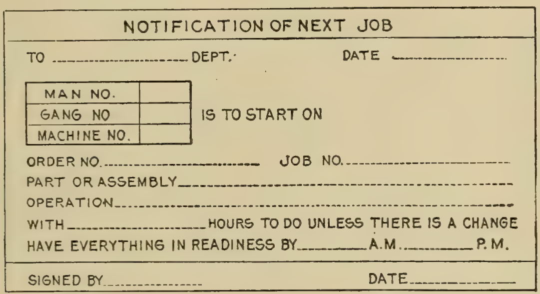
C Hours of work for which material is actually available at machine, as shown by heavy or full green line.

694 Manufacturing Schedules Showing Dates Work Should Start and Finish, with Provision for Showing Progress. See Figure 3, Chapter VI, and Figure 109, Chapter XX, as regards the progress feature. This may be indicated by drawing dotted lines under full lines.

695 Schedules for Purchasing Department, Pattern Shop, Foundry and Tool Room. Reference to Figure 25, Chapter XIII, will show a schedule of purchases graphically presented. This same form of scheduling may be made for pattern shop, foundry and tool room, and can be modeled after the Manufacturing Schedule, Figure 3, Chapter VI.

696 How Much Work is Ahead of any Machine. To determine the work ahead of any machine, reference would be made to Control Boards, Figure 11, Chapter XI, and Figures 105, 106, 107 and 108, Chapter XIX, or to Planning Sheet, Figure 115, Chapter XXI. In the former, the length of the strip not covered with black would indicate the work to do; in the latter, lines which have not been canceled. Anticipated as well as actual material available would be considered in both cases.

697 How Much Material is Actually at any Machine. This will be shown by heavy green line on strips.



NOTIFICATION OF NEXT JOB

TO .... DEPT. DATE ....

MAN NO.	
GANG NO	
MACHINE NO.	

IS TO START ON

ORDER NO.................... JOB NO....................

PART OR ASSEMBLY....................

OPERATION....................

WITH .... HOURS TO DO UNLESS THERE IS A CHANGE

HAVE EVERYTHING IN READINESS BY.......... A.M. .... P.M.

SIGNED BY.................... DATE....................

Figure 114. Form to Give Notification of Next Job

698 Sequence of Jobs. In Figure 110, Chapter XX, it will be noticed that there is a reference to "next operation." This furnishes the means for determining the sequence of operations on a job as it appears on a board. If it is sequence as applying to a part, the "Progress Record," Figure 21, Chapter XII, will supply it. If it is sequence of work at machine, the relative position of the strips opposite a machine or working space will show it. See Figure 93, Chapter XVIII.

699 What Job is on Machine, and if there are Others, the Order of Their Importance. The strip opposite a working space, under the current date, unless signaled for delay, is the work on a machine, as well as the time cards at the top of the clips on dispatch boards (Figures 9 and

10, Chapter XI) and in job holders (Figure 70, Chapter XVI). Succeeding strips and cards indicate order of importance of work.

700 What Orders on any Particular Machine are Held Up for Tools. As work is stopped in plant because held up for tools, the strip on Control Board is signaled in yellow. (Figure 13, Chapter XI.) A signal of the same color is put on the Production Order over the corresponding figures representing the cause (Figures 15 and 16, Chapter XII), so that while the board shows the equipment held up for tools, the orders also show it.

701 When Tools are Received. As the Dispatch Stations are clearing houses for all jobs, in covering starting and stopping time, inspection and movement of material, it naturally follows that as soon as tools are received this fact is known, the Control Stations are advised and the signals taken from both boards and orders.

702 When it is Necessary to Get More Material to Prevent Breaking Down a Machine for a Different Job. One of the best means for determining when materials are running low is to watch the relation between the black and green entries on strips. If there is no material, there is no green. If there has been material and the operator is working at a faster rate than material is being received, the gap between the right-hand edges of black and green entries begins to close up, and when it is apparent that material is running low, the strip and Production Order are so signaled.

703 When Material has Arrived. The Move Order (Figure 34, Chapter XIII) is the basis for checking material receipts on boards. As work is completed and inspected Move Orders are made out and work moved, and the arrival at any point is a matter of record.

704 When it is Necessary to Get More Orders to Keep Certain Machines Busy. The fact that strips on boards are conspicuous by their absence is sufficient indication that work is running low, and the board is signaled accordingly. In all such cases the production control supervisor should do one or both of two things:

A Rearrange schedules so as to supply work from busy machines.

B Take up with the management the matter of needing more work.

705 WHAT MACHINES ARE IDLE, AND FOR HOW LONG. These are indicated by blank spaces on boards or by signals on boards showing idle time.

706 WHETHER MACHINES ARE IDLE FOR: BREAKDOWN, ABSENT WORKMEN, WORKMEN ON MORE IMPORTANT WORK, NO WORK, WAITING FOR TOOLS OR DRAWINGS, WAITING FOR INSPECTION, SETTING UP, NO POWER, WAITING FOR CRANE. For key to signals for idleness or irregular conditions, see Figure 13, Chapter XI.

707 WHEN MACHINE STARTS AGAIN AFTER DIFFICULTY IS REMEDIED. Through notification to Dispatch Stations and advising Control Stations.

708 WHEN MACHINES HAVE BEEN REPAIRED. Repair orders as completed pass through Dispatch Stations, and Control Stations are promptly notified.

709 CONTROL OF MATERIAL MOVEMENT. The Control Boards furnishing bird's-eye view of shop conditions and supplying mechanism for manipulation, with the Dispatch Boards as the points of contact between the equipment, the workers and the Control Boards, a way is provided for controlling the movement of material through the medium of Move Order. (Figure 34, Chapter XIII.)

710 CONTROL OF INSPECTION. The same argument applying to Control of Material Movement covers Control of Inspection, except that the medium is Figure 24, Chapter XII.

711 WHAT MACHINES ARE MOST CONGESTED. Too much work assigned to a machine results in congestion, and this is indicated graphically on Control Boards by spaces being completely filled with strips, with more work ahead in pockets at side of board. See Figure 107, Chapter XIX, referring also to Figure 115, Chapter XXI.

712 WHETHER WORKMEN ARE AHEAD OF, OR BEHIND, SCHEDULE. Obviously there are two kinds of efficiencies—that of work and that of worker. To watch that of the latter, reference should be made to Figure 158, Chapter

XXVI, and its supporting text. It is true, of course, that strips on Control Board, in so far as the relation of black entry to date plumb line is concerned, will furnish an index as to the efficiency of the worker, and any cases of slow operators would be signaled in brown; but, as stated in Chapter XXVI, the real efficiency of a worker must be considered from the standpoint of the worker as distinct from that of work.

713 If Production is Falling Behind, and Where. A glance between the date plumb lines on the Control Board will show whether worker is ahead or behind schedule, and what work is affected if behind. See Figure 93, Chapter XVIII. See also the "anglegraph" (Figure 20, Chapter XII), and Material Control Sheet mechanism for coördinating time and quantity (Figure 40, Chapter XIV).

714 Whether Orders are Broken into More Than Necessary. When changes are made in jobs for one reason or another, the strips are either placed in a different position on the board or removed from the pocket altogether and placed with other strips for work ahead. The corresponding changes must also be made on Dispatch Boards. Time Cards would also be changed as work is changed, from all of which it would be known what changes are made from time to time, and where they were made; and if reports were compiled as to changes, they would be available in showing the tendency in this direction.

715 Time when an Operation Must Begin. Reference to Figure 3, Chapter VI, and Figure 109, Chapter XX, will indicate one means of determining when work must begin. Figure 93, Chapter XVIII, illustrates another method of determining starting times. Both figures show that left-hand edges of strip are set under times work is to begin. See also Figure 115, Chapter XXI.

716 Standard or Estimated Time Set for Doing Work. The length of strip indicates this, being cut to the length determined by dividing pieces to be done by pieces per hour. See Figure 93, Chapter XVIII.

717 Actual Time Spent in Doing Work. This is shown by Time Cards (see Chapter XVI). It is also shown by

Record of Progress (Figures 20, 21 and 22, Chapter XII, and Figure 124, Chapter XXI).

718 WHEN NECESSARY TO REVISE SCHEDULES TO RELIEVE CONGESTION OR TO MEET CONDITIONS CAUSED BY ABSENT WORKMEN OR BREAKDOWN. Colored signals show in a most comprehensive and graphic manner the irregular conditions usually met with in industry. Idle time, because no work is scheduled, is shown by gaps between, or by absence of, strips. Congestion is shown by too many strips. With these evidences in plain sight, it is but a step in revision to scheduling.

719 PROPER ROUTING. Read this chapter on The Use of Control Mechanism in Planning (XX), and see Figure 93, Chapter XVIII.

720 WHERE INSTALLATION OF ADDITIONAL EQUIPMENT WOULD BE ADVISABLE. By being able to know in advance, through graphic features, that there is congestion in equipment, and because it will be difficult to get work on time because of this congestion, it can be determined, upon analysis, where additional equipment is needed, and the kind.

721 DELAYS BETWEEN OPERATIONS. Delays between operations would be shown by spaces between strips. Delays in the operations themselves would be shown by signals illustrated in Figure 13, Chapter XI.

722 WHETHER ADEQUATE SUPPLY OF MATERIAL IS ON HAND. This would be determined by excess of green entry over black entry on strip, and by how much faster operator was working over standard hourly production determined upon.

723 EXACT SHOP CONDITIONS OF ANY CLASS OF PRODUCT, OR ANY ORDER. The Control Boards are in themselves a mine of information as to the condition of orders and products. Take strips covering erection work, for example: in knowing how far ahead or behind the work is, and approximately when completion will be made, we have a most excellent idea as to conditions. This applies as well to assembly and machine operations. Progress Records, Figures 21 and 22, and the "anglegraph," Figure 20, Chapter XII, will indicate how conditions can be determined. See also Figures 38, 39 and 40, Chapter XIV. Reference

to Figure 93, Chapter XVIII, will assist in the matter of studying conditions of work. See also illustrations, Chapter XXI.

724 Comparisons of Machines by Departments. Study of Chapter XV, on Equipment, will show how comparisons of machines by department can be made up, not only as to work done, but as to idleness. In fact, Efficiency Reports, determined by dividing time actually worked by time possible to work, can easily be made out covering equipment. Study of the different Control Boards will also show how comparisons can be made among different groups of machines.

725 Location of any Order. Production Orders (Figures 15 and 16, Chapter XII), in connection with Progress Records and "anglegraph" (Figures 20, 21, and 22, Chapter XII), will determine the location of any order in the plant, and its condition.

726 Completion Percentage of any Order. Knowing the amount of work to do on any order, and its progress, which automatically determines balance to be done, it is easy to work up Completion Percentages. (See Figure 20, Chapter XII.) The relation of black on strips to length of strips will show completion ratio, which can be figured if desired.

727 Work Released for Next Operation. Any work done by one operation, credited in black, releases work for the succeeding operation, entered in green, in terms of the standard hourly production of the succeeding operations. (See Figure 93, Chapter XVIII.) Material may be actually on hand or anticipated, and is shown by full-green or half-green entry, as indicated in Figure 88, Chapter XVIII.

728 Standard Hourly Output of Each Machine. This is shown on all strips. See Figure 110, Chapter XX; also Figure 17, Chapter XII.

729 Sequence of Operations for any Class of Product. All strips show reference to "next operation," which will facilitate a study of sequence. See Figure 93, Chapter XVIII.

730 Date a Particular Order Will Go to a Machine.

Left-hand edges of strips determine this. See Figure 109, Chapter XX.

731 PROBABLE TIME OF COMPLETING AN ORDER. This is indicated by red sliders with pointers behind strip at right. See Figure 13, Chapter XI, for key to signals; also Figures 82 and 83, Chapter XVIII.

732 HOW MANY MORE OPERATIONS ARE YET TO BE PERFORMED ON AN ORDER. Progress Records show this. (See Figures 21 and 22, Chapter XII.) Strips on boards will also show this information. See Figure 93, Chapter XVIII.

733 WHERE TO APPLY EFFORT TO SECURE AN EVEN FLOW OF PRODUCTION. The boards show where work is out of balance, some machines having too much to do and others not enough. Being able to anticipate this, re-scheduling can be arranged for, so as to result in a more even flow of product.

734 In using the control mechanism described in this book, it should be kept in mind that the requirements in a given case must determine what to use. *Not all of the devices and records shown would be used in any given case;* for instance, if Control Boards are used, Control Sheets (Figures 38 and 39, Chapter XIV) would be unnecessary. If they were used in place of Control Boards, Figure 112, Chapter XX, would not be needed. The "anglegraph," Figure 20, Chapter XII, would not be required if other forms of Progress Records were used. The Material Control Board (Figure 119, Chapter XXI) would not be needed with Material Control Sheets (Figures 38 and 39, Chapter XIV).

735 What has been attempted in the presentation of all this material is to show the wide use of graphics in Production Control, so that, regardless of conditions met with, some application of the principle of visualization can be worked out.

Chapter XXI

AUXILIARY PLANNING MECHANISMS

736 In discussing the twelfth law of Graphic Production Control, in Chapter VI, on "Succeeding Operations," this statement was made:

> "Multiplying the time finished at any operation by its ratio will give the available time for the next operation, through which we can always have an inventory of labor, the same as we have an inventory of material."

737 Planning Sheet. In Figure 115 is illustrated a planning sheet based on the use of this principle of ratios, which, as will be remembered, is found by dividing a succeeding operation time by the preceding operation time. In the use of this sheet for planning, two important rules must be taken into consideration:

A A job having six operations is available if the material is on hand, *but only as regards the starting operation.*

B All operations following the first are available *only when they receive from preceding operations all or part of the material called for.*

738 Let us briefly consider the basic principle of this planning sheet before we attempt to explain the entries on Figure 115. Assume that two operation times are 10 hours and 16 hours respectively, as shown in Figure 115A. This means, from the rule governing succeeding operations, that the ratio is 16 divided by 10, or 1.6; or, for every hour worked at "this operation," 1.6 hours of work are released for the "next operation."

739 Why not Enter Work to Succeeding Operations

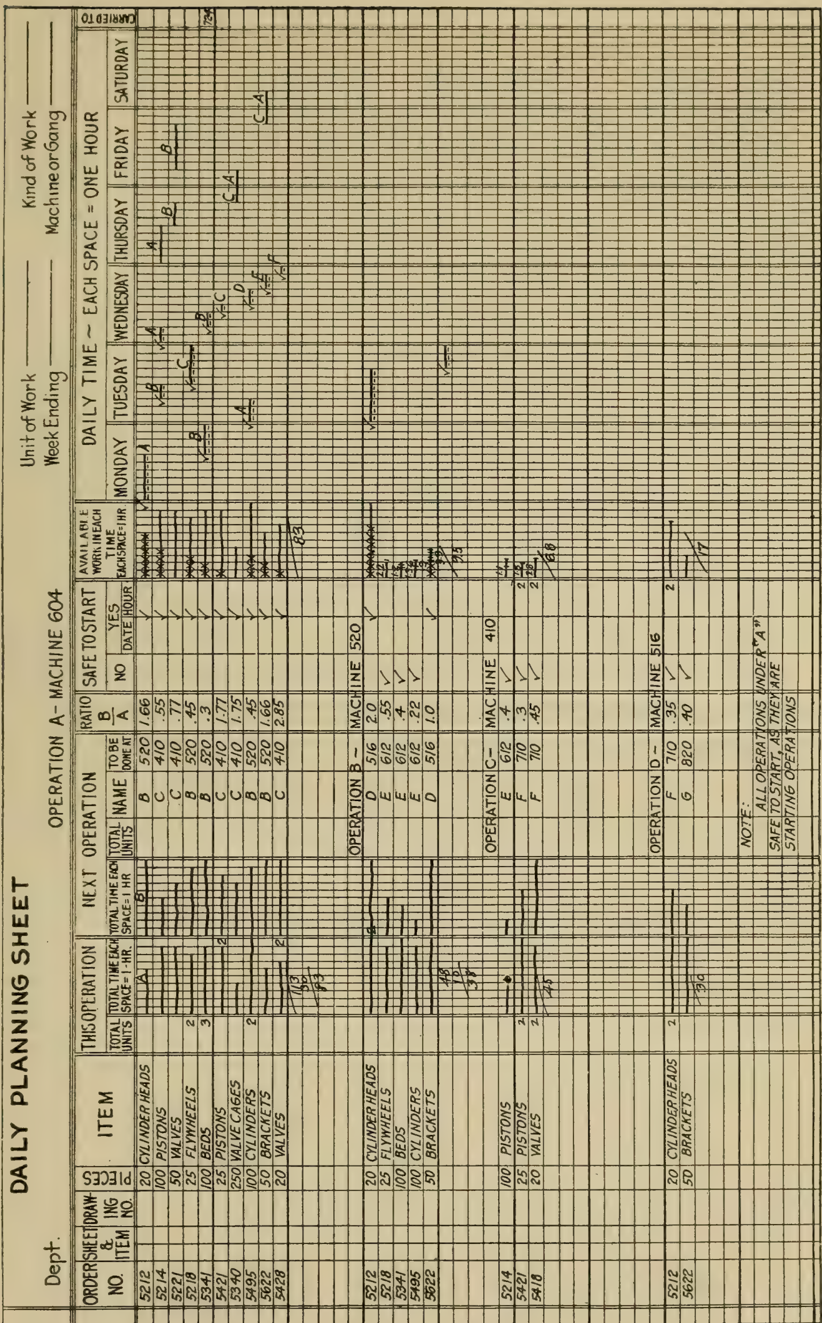


FIGURE 115. PLANNING SHEET PLOTTED BY USING RATIOS

AS RELEASED? Assume that the workman on "this operation" does four hours of work. Multiplying 4 hours by 1.6 equals 6.4 hours for the "next operation." In other words, we credit for 4 hours and charge for 6.4 hours, which we can show graphically in Figure 115B.

740 A brief description of the procedure is now in order. Each machine, gang or man is to have a planning sheet, which is to cover the work of a week at a time. No work is to be entered on the sheets that is not available as defined in the first definition given above.

741 When available work is selected for starting, the information covering the *first operation only* is to be en-

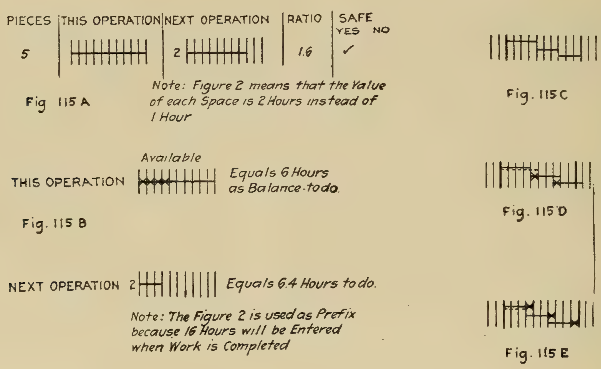


FIGURE 115A TO E. GRAPHIC ANALYSIS OF BASIC PRINCIPLE OF PLANNING SHEET

tered on the planning sheets. Succeeding operations will be entered as work is released from preceding operations. In making an entry, the order number, sheet and item numbers, drawing number, piece, and description of items are to be entered. Under "this operation" are to be entered the number of units (by units is meant work to be done, such as 100 rivets, 20 feet calking, 50 holes, etc.) and the total time. Under "next operation" are to be entered total time, units, name of operation and where work is to be done.

742 Times for both "this" and the "next operation" are to be expressed by lines, each space equaling one hour. In cases where the time is greater than 10 an index figure is to be placed at the left of the line, indicating that the value of each space is *one hour multiplied by the index figure*. To

show 34 hours, a line would be drawn through $8\frac{1}{2}$ spaces prefixed by the figure 4.

743 Because the selection of a succeeding operation depends entirely upon the relation between its time and that of the preceding operation, the ratio between the two should be established in all cases by dividing time of succeeding operation by time of preceding operation.

744 The amount of work available in time should be shown by a line under "available." For starting operations this would equal the times entered under "this operation," unless some part of the material was not available. For succeeding operations the amount of work available in time would depend upon what was released from previous operations. For work done at any operation the amount available for a succeeding operation would be: Hours of work done $\times$ Ratio = Hours of work available for succeeding operations.

745 If the ratio was 0.7 to 1.0, indicating that for every hour of work done, 0.7 hour is released, and if the work completed in time was 6.7 hours, 4.7 hours would be available for the succeeding operation (6.7×0.7). If it is not safe to schedule succeeding operations (and this is the case where ratios are less than 1 to 1), a check mark is to be placed under "No." When a job is safe to start, the approximate date and time are to be entered under "Yes."

746 As jobs are selected for starting, a line is to be drawn under the proper day opposite the item to be worked upon. The *starting-point* is to depend upon previous work planned for the same day. Its length is to depend upon how long the shop management wants a gang or machine to work on the operation. Entries are to be made in pencil. If a change is necessary after the planning has been done, the line can be erased and a new one drawn.

747 Upon completion of work as shown by time cards turned in, entry is to be made on planning sheets. Entry will be on the principle that any work completed at one operation is available in whole or in part for the next operation. Therefore, for any given operation, the time as shown by the time cards turned in is to be entered in the form of a dotted line under the proper line scheduled for the day, and

then crossed from the line under "available," which will then show the net time now available. The number of pieces and units of work completed are to be deducted and correct balances shown.

748 Information under "next operation" will now be noted and transferred to the sheet covering the gang or machine that is to perform the next operation. The time turned in covering the operation just completed is to be multiplied by the ratio factor, and the result drawn under "available" on the sheet covering the "next operation." Check marks are to be placed in front of the lines showing scheduling for the day, when the men start work.

749 From this detailed description, the entries on the planning sheet illustrated can be easily followed and understood. The sheet shows that the scheduling for Monday, Tuesday and Wednesday was followed as planned. Further, on Thursday morning the scheduling has been arranged to carry through until nine o'clock on Saturday morning.

750 An advantage in using the sheet as described is that it makes no difference in what order the various items of work to be done are entered on the sheets. The lines under the proper day show the selections, and the relative positions determine the sequence of jobs. Further, if jobs have been scheduled and change must be made, no rewriting is necessary. *Simply rub out one line and draw it somewhere else.*

751 Because there are bound to be variations in times worked as against times scheduled, it may be well to explain how this is handled. Assume that the scheduling is as shown in Figure 115C, and that instead of taking 4 hours on the first item, the man takes 5 hours. The entries would be changed as shown in Figure 115D; if he took 3 hours, the arrangement would be as illustrated in Figure 115E.

752 The thing to do is to assign the work where it should go, and as soon as congestion is noticed steps can be taken to relieve the situation.

753 Reference to the planning sheet will show the following information:

Operation	Work to Do "this Operation" Hours	Work Available Hours
A	83	83
B	38	9.5
C	45	6.8
D	30	17.0
	196	116.3

—which shows that there is less than a day's work at machines B and C and over a week's work at machine A. Consequently, to relieve the situation, work on 5341, operation A, has been transferred to machine 724 as shown. This is not only extremely valuable in keeping close watch over congested places, *but answers the objection often advanced by shop men that out of a number of machines they do not know to which to assign certain work.*

754 Instead of showing four planning sheets covering operations A, B, C and D, in Figure 115, they have all been entered on the same sheet. For each day sequence of jobs is shown by letters.

755 Planning Sheet. In the description of the planning sheet illustrated in Figure 115, we considered work as expressed in time. Figure 116 is a graphic planning sheet in which the control is according to pieces. As will be seen, the quantities are entered progressively under the proper dates, machining of parts under one set of dates and assembly of units under another set of dates. The heavy black vertical lines show the current dates for machining and assembly, from which it will be noted that two days have been allowed between finishing of machining and starting of assembly. The heavy black horizontal lines are the relative accomplishments in pieces to the pieces scheduled, and the relation of these heavy black horizontal lines to the heavy black vertical lines establishes how far ahead or behind (in pieces) the work of machining and assembly is. This is a simple but extremely valuable graphic presentation.

756 In Figure 117 we work in pieces and hours both, by bringing in the element of pieces per hour (standard hourly production). The principle is that by constantly knowing

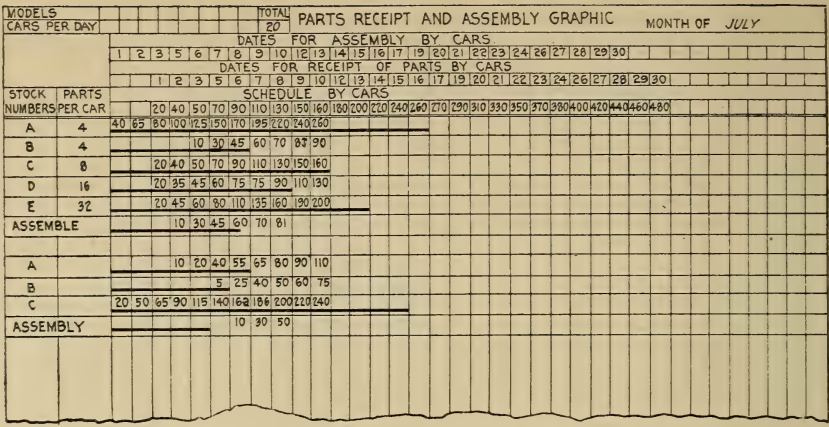


FIGURE 116. PLANNING SHEET PLOTTED ON BASIS OF QUANTITIES

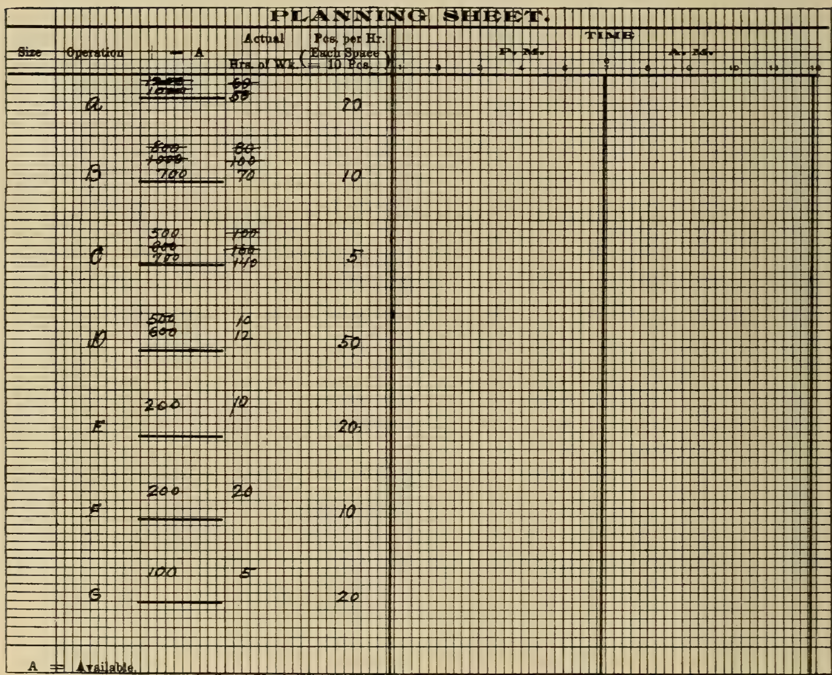
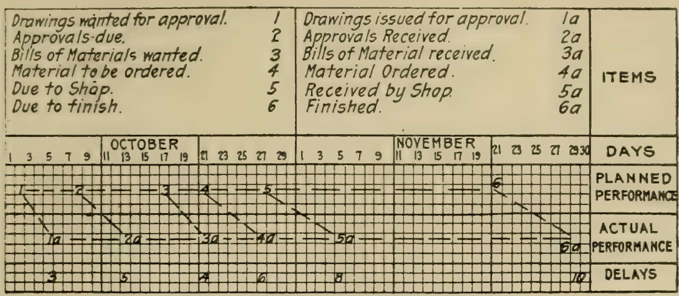


FIGURE 117. PLANNING SHEET PLOTTED BY USING BOTH RATIOS AND QUANTITIES

changing balances of material in pieces, we can always know our hours of work ahead by dividing pieces to do by

pieces per hour. As will be noted in the illustration, we had 1200 pieces and 60 hours' work to start with at A. We finished 200 pieces, deducted them from A and added them to



NOTE:– Slant of Lines indicates Gains or Losses.

FIGURE 118. PROGRESS CHART PLOTTED WITH INCLINED LINES

B, and multiplied the new balances, giving us 1000 pieces and 50 hours at A and 1000 pieces and 100 hours at B. We finished 300 pieces at B, deducted them and added them to

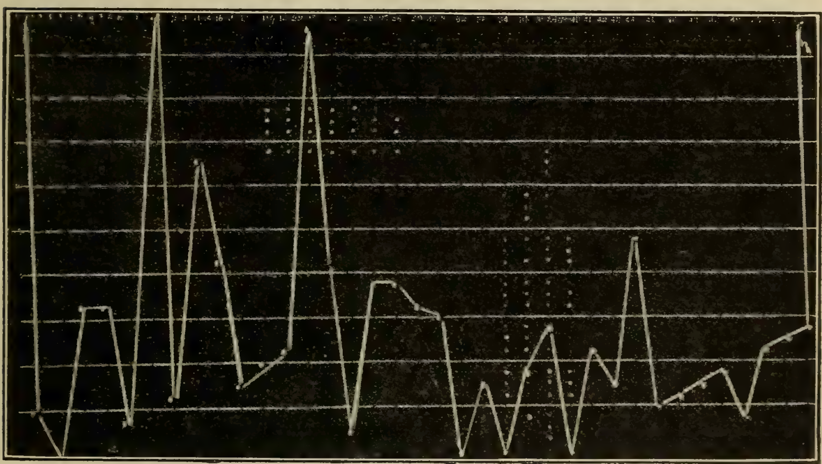


FIGURE 119. MATERIAL CONTROL BOARD USING SLIP STRING

C, and the times become 70 hours at B and 160 hours at C. From this point further study is a simple matter. At the right of the sheet is a space for daily planning. As selections of work are made, they are indicated by drawing a line opposite the operation, the length indicating the time

work is to be carried on, the edges indicating starting and finishing times.

757 Progress Sheet. Figure 118 is a simple form of following up a given schedule and is self-explanatory. The graphic feature is the ability to determine the tendencies by the slant of the vertical lines.

758 Material in Process Board. The illustration at Figure 119 shows a board the principle of which is a white elastic slip string hung over movable pegs. As material is reduced at one place, it automatically increases *by the same amount* the material at the next point, and so on through the operations, departments, machines or materials. *Note the value of the visualization.* Machines or operations are shown across the top. Pieces, dozens, hours or tons are shown down the sides. The elastic string over the pegs shows the work ahead. Faint line is danger-point. Pegs are moved continuously throughout the day. The board shows that 1–8–11 to 14–23 and 52 are very much overloaded, with all points below faint line requiring work.

759 Reminder Board. To furnish the executive general controls so as not to burden him with details and yet enable him to watch progress and exceptions, he should have a board like that illustrated in Figure 120, wherein different colored buttons cover the main things to watch, such as—

Engineering work to start.
Shop work to start.
Assembly work to start.
Shipment to start.
Erection to start.

760 With a plumb line moving to the right one space each day, the buttons to the right of the plumb line will show what is due to happen for the next and subsequent days, as well as what is behind as shown by buttons to the left of the plumb line.

761 Labor Board. Figure 121 is a board which covers construction and repair gangs, or pipefitters, carpenters or electricians, where in a large plant the problem is one of locating gangs and knowing what they are doing. The numbered labels show the numbers of the gang foremen,

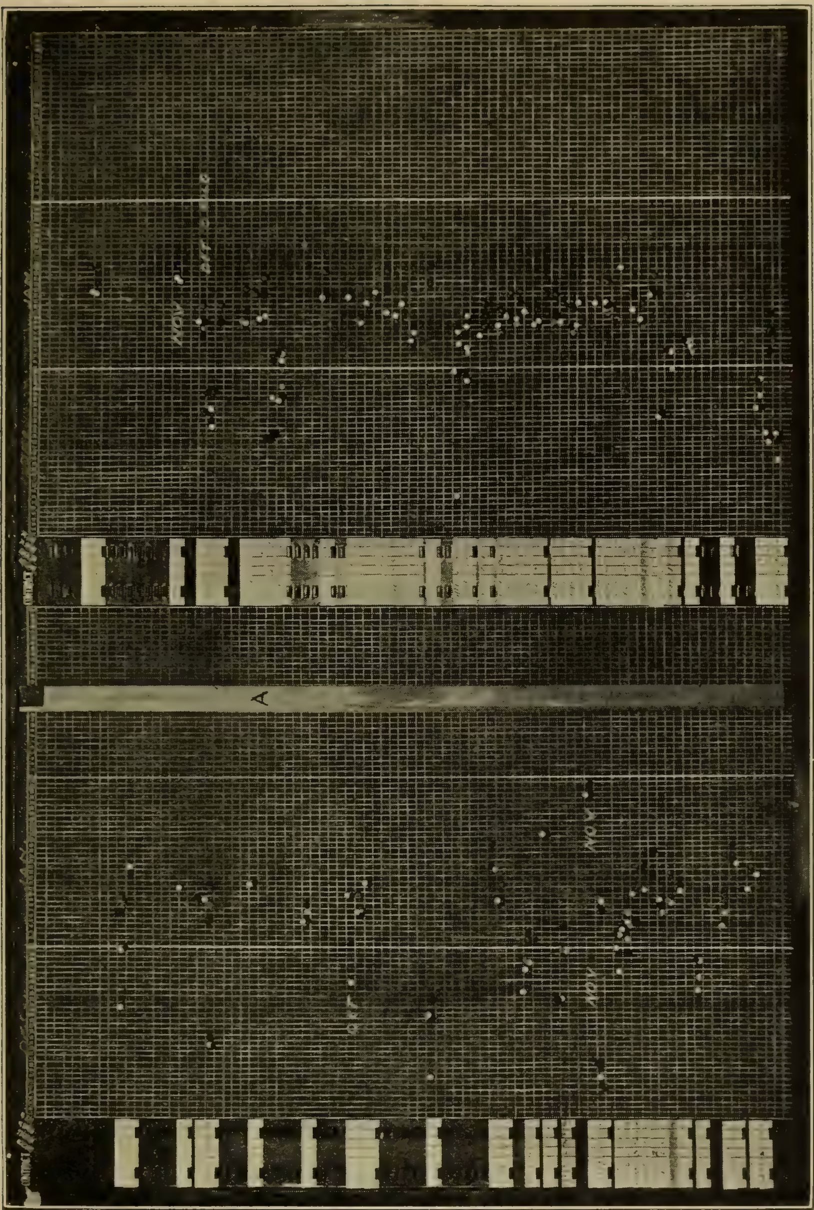


FIGURE 120. REMINDER BOARD PLOTTED WITH LARGE-HEADED PINS

under which are the buttons showing the numbers of the men in the gang. The clip at the right of the buttons covers

the order being worked on, with the next clip covering the order for the next job. If an emergency call comes in or rush work must be undertaken, it is an easy matter to locate gang leaders and men and to find out what is being worked

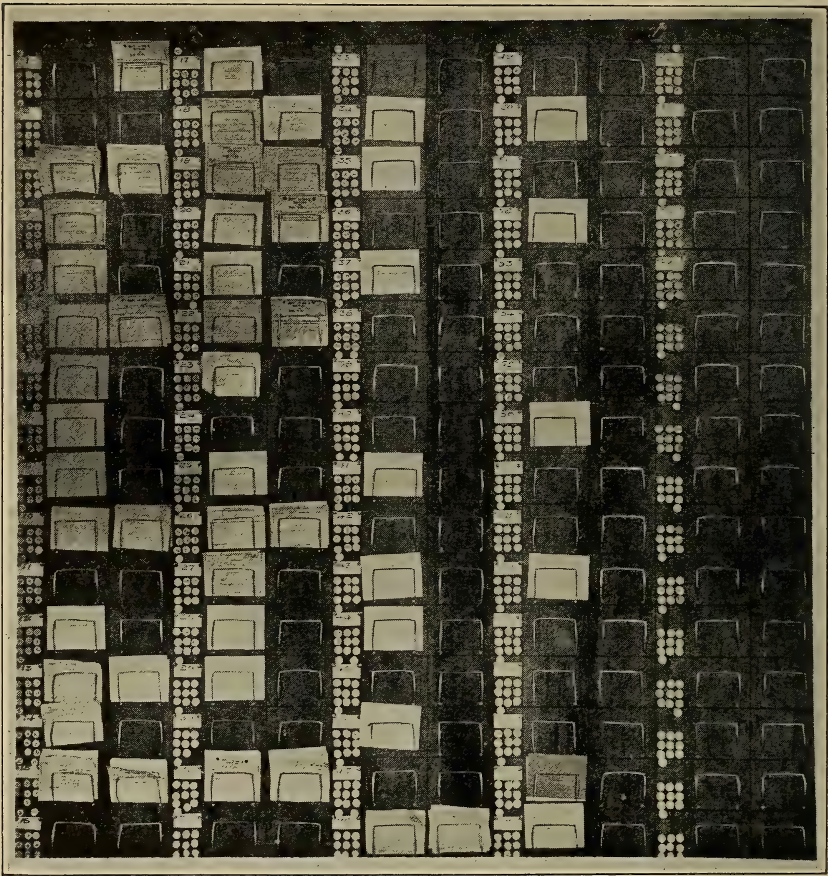


FIGURE 121. LABOR BOARD

on and what is to follow, from which revision in schedule can be arranged for and men quickly changed.

762 CONTROLLING THE MELTING OF BRASS. Where many metallic alloys are required to pour variety of molds of day's production, it is necessary that time of conversion of this metal be synchronous with actual production of miscellaneous molds. The Metal Stores Department must make up metal charges in accordance with weight and analysis

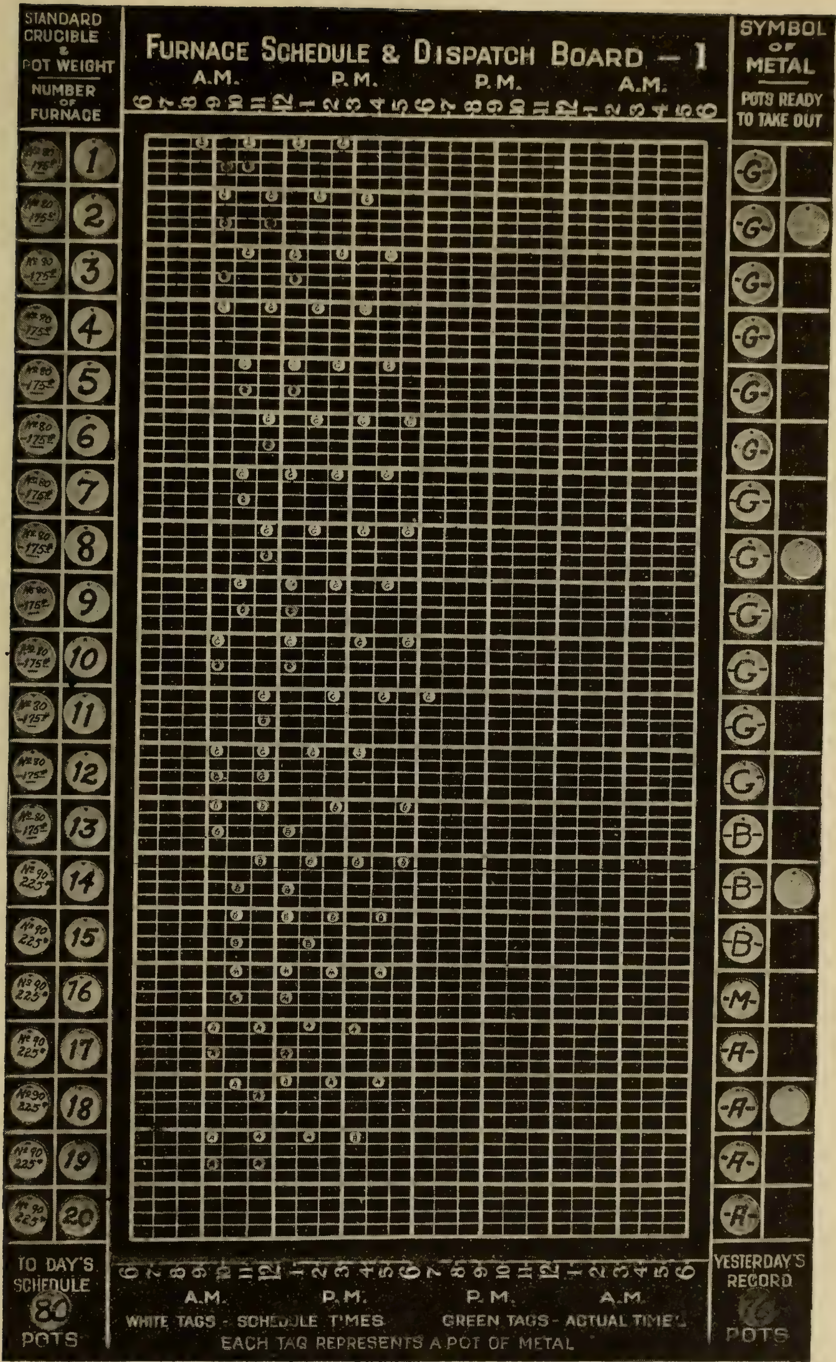


FIGURE 122. METAL FURNACE CONTROL BOARD

requirements. Melters and pourers must have knowledge of requirements they are to fulfil, as well as knowledge of the times when pots of metal will come out of furnaces. In emergencies it is also possible to shift jobs temporarily so that metal requirements will correspond with what furnaces have been able to melt; but this, it will be understood, is the sort of compromise which a furnace control and dispatch board aims to eliminate.

763 Furnace control and dispatch boards (Figure 122), adapted to requirements of one case, have available means for controlling operations of forty furnaces. Twenty furnaces are handled by each board. Numbers of furnaces are consecutively arranged up and down left-hand edge of boards, each furnace taking up a space of three inches, measured vertically, making total length of vertical coördinate sixty inches.

764 Horizontal coördinates of furnace control and dispatch boards are divided into twenty-four spaces, each 1¼ inches long and representing one hour. The total length of horizontal coördinate is thirty inches, or space for entire twenty-four hours of one day. At top of board consecutive hours are marked, starting with six o'clock and progressing through twenty-four-hour period.

765 It will now be evident that each hourly space on scales takes up 3 inches in a vertical direction by 1¼ inches in a horizontal direction. These spaces are subdivided vertically into four ¾ × 1¼ inch spaces. The top space represents the even hour, the second the fifteen-minute period, the third the half-hour period and the fourth the three-quarter-hour period.

766 In each of the quarter-hour spaces explained above, arrangement is made for attachment of a ¾-inch round disk tag. On the face of this tag are incorporated symbol of metal and size or weight of standard pot of metal which it represents. Tags are of two different colors, those representing schedule of heats and those representing actual taking-out time of pots.

767 Since stopping and starting times of consecutive heats should be as nearly synchronous as possible, it is evident there will be no use for signals indicating starting time

of heats. It is also evident that economy of gas or coke requires continuous operation of furnaces.

768 On right-hand edge of control board is arranged space for two-inch yellow tags, which are suitably displayed in order to signal *readiness to pull out* of each pot of metal. These signals are large and can be seen for full length of molding floors. This feature gives pourers time to get ready, to anticipate and save time, and to know what kind of metal they are to pour next.

769 Furnace control and dispatch boards are handled in the following manner: Total weights of metals of several specifications required to pour day's production of molds are first figured out. These metals are now reduced to so many standard pot weights of each; that is, 175, 300 or 350-pound pots, according to furnace and pot in which it is to be converted.

770 Knowing that molding floors can accommodate certain reservoir capacities of unpoured molds, but that we should keep floors as clear as possible, we must adjust pulling-out times of pots of metal of various specifications with actual molding production. We, of course, consider record times for conversion of metal of the several analyses. It only remains for us to adjust our furnace schedules to meet these conditions.

771 A small paper chart is used for laying out furnace schedule. It is an exact duplicate in miniature of furnace control and dispatch board. Kinds of metal, sizes of pots and pulling-out times are registered thereon. After completion, it is taken to furnace control and dispatch board and matter is copied from chart on board,—only now we do operation mechanically. Yellow tags, giving symbol of metal and pot weight, indicate scheduled times of pots, and are, accordingly, posted on time scales as production to fulfil.

772 During day's operations, actual pulling-out times of pots are indicated by posting green tag, which also gives symbol of metal and pot weight. A comparison between green and yellow tags indicates whether schedule has been fulfilled or not. In order to enable pourers to get certain things ready,—that is, to visualize which floor is most con-

gested and requires preference in pouring, to order placing of mold weights, to supervise tempering of metal if necessary, and many other things,—a *pot's readiness to pull out* is signaled at board by large 2-inch yellow tags. This is done about five minutes before operation of pulling out, and thus many delays are anticipated.

773 CONTROLLING THE MANUFACTURE OF HEAVY, COMPLICATED MACHINERY. Take the case of a large firm manufacturing heavy, complicated machinery of many designs and sizes. The nature of this type of manufacturing leads to a vast amount of engineering detail connected with specifications for standard and special apparatus, and the economical interlocking of the elements of these designs, so that a minimum number of different parts would have to be processed. The daily improvements in the methods of manufacture and the frequent changes in the products present a varying element that makes difficult all centralized, automatic production-control schemes.

774 To keep in touch with the productive activities of thousands of employees, spread over acres of floor space and subdivided into hundreds of sections which are making different articles, is a problem that is not easily solved by a Control Department. The methods commonly used in smaller shops hardly apply in a plant of this size, for to consolidate the detailed functions of scheduling and dispatching within the limits of one department would necessitate a large and unwieldy clerical force. Again, the remote control arising from the physical nature of the central office plan would require that the clerical force have an unusual education in shop detail, for otherwise the records of the department would undoubtedly show work planned after the actual production had taken place. These considerations emphasize the fact that to have an economical central production department, a scheme of control would have to be devised which would be flexible, free from engineering and shop detail, an exact measure of the productive ability of a manufacturing unit, and which by balancing orders with production would give the supply and demand factor of a section.

775 A statistical method of production control, founded

on the "anglegraph" principle, would meet those requirements and is here explained in this connection.

With the elimination of manufacturing and shop detail, the central production department confines itself to being a link between the sales and manufacturing departments, and has supervision over where and when the products of the company should be made.

776 The first function requires a full knowledge of the types of manufacturing carried on in the different sections and an intimate contact with the department of manufacturing operations, inasmuch as the Production Department prepares its routing from layouts made by the former. In the matter of when a product is to be made the Production Department reigns supreme, for no contract or order is binding on the company until the Production Department has ratified the delivery date thereon. This does not preclude the Sales Department from quoting in a general way when delivery may be expected and having the Central Production Office send through the scheduled day of delivery somewhat later.

777 The records of the Central Production Office consist almost entirely of the statistical charts. On account of the vast amount of detail in regard to engineering specifications, an order, before being put in process, is reviewed by the Engineering Department, and a complete description of the parts entering into the assembled machine are detailed as to quantity, purchaser, type of machine, drawing and item, specifications and total quantities for one unit. The storekeeper assigns a shop order number, the Production Department adds the routing, and the Department of Manufacturing Operations, the tools and patterns. The information division of the Central Production Office then prepares a complete write-up of these details and sends a copy to each of the manufacturing departments concerned. In the case of an order repeating itself, this procedure is curtailed to an indication of what is wanted. Orders for special equipment must be worked up in detail before being put in work.

778 As manufacturing is progressive and goes forward day by day, the Central Production Office must have a

means of judging the productive activities of the units making up the whole works. This department, in passing the orders from the Sales Department to the shop, is interested

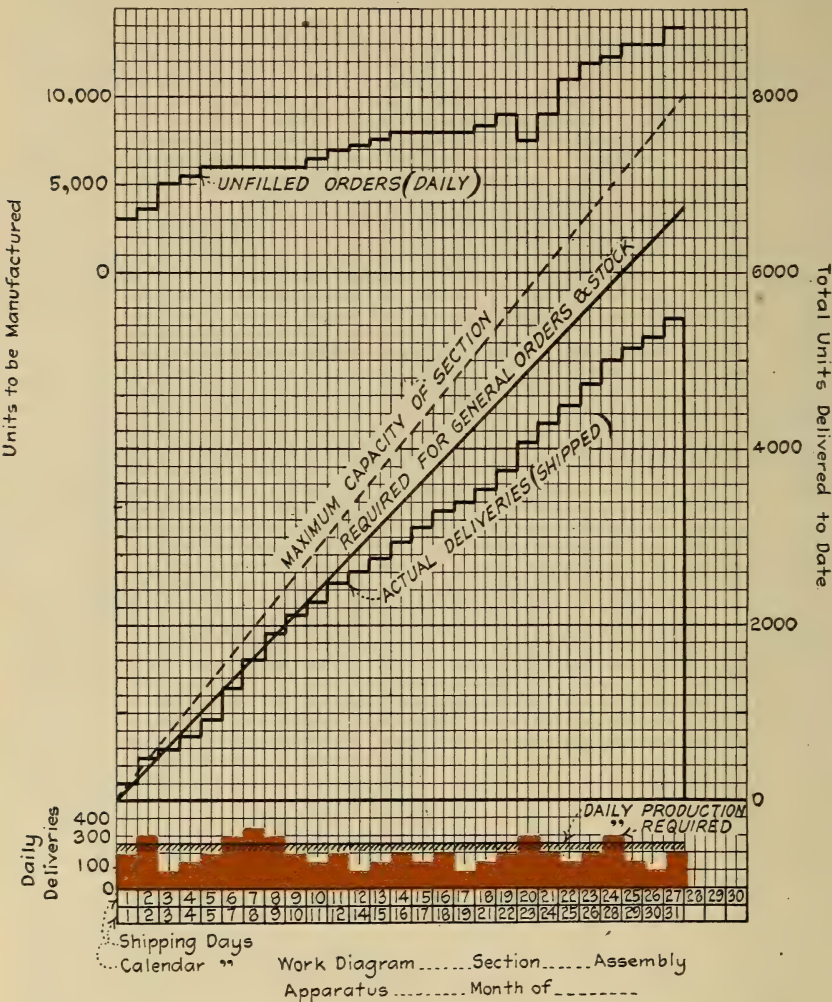


FIGURE 123. CAPACITY CHART COMPARING DELIVERIES, REQUIREMENTS AND MAXIMUM CAPACITY

in the unfilled orders ahead of a section, and the actual production taking place.

779 Figure 123 shows what can be termed a work diagram. The Central Production Department, in considering the orders ahead of the section at the beginning of the

month, has set a task of 6750 units, which means a production of 250 for each working day of the month. The cross-hatched line at the bottom of the sheet shows the number required daily, and the inclined line marked "Required for

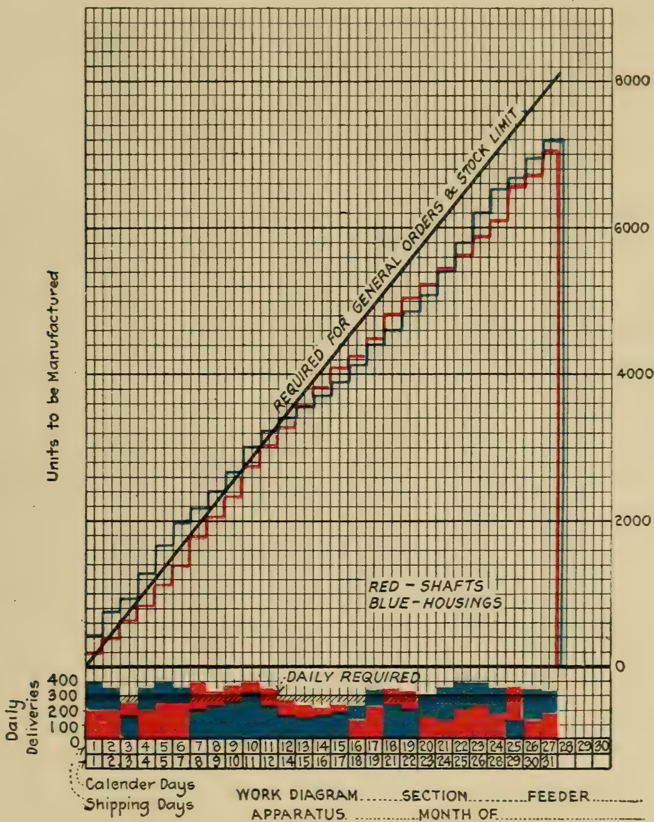


FIGURE 124. ANGLEGRAPH PROGRESS CHART

general orders and stock" is an extension of this demand and forms the normal schedule line of the section.

780 As production takes place, the daily amount is blocked out in color and the irregular line of actual deliveries started. On the chart shown, the requirements set by the Central Production Office are below the maximum capacity of the section, and the actual deliveries of assembled apparatus have fallen below the normal scheduled line. At the bottom of the page is shown the progressive cal-

endar for the unfilled orders ahead of a section, other than those being processed during the current month.

781 The information contained in the assembly chart of a section is invaluable to the Central Production Office. It furnishes a measure of sectional capacity and is a simple means of feeling the pulse of production. The data contained thereon render the setting of a monthly load schedule infinitely easier than the most extended calculations. The maximum capacity of a section is found by records of its past performance, and the task loads are set according to this and unfilled orders.

782 The Central Production Department limits its activity to assembled units, and has within every main section of the company a chief production clerk who distributes work to the feeder sections under his control. The works are divided into distinct manufacturing units based upon assembled product or operation. In either case complete systems of planning, such as dispatch boards, machine layouts, and control boards, are used by the chief production clerk to lay out the work.

783 Figure 124 is the ''anglegraph'' of a feeder section. The task has been set at 300 a day by the chief production clerk, who has found, on consulting his storeroom stock, that this number of parts will have to be made to replenish the store's stock and meet the general orders. Here the ''anglegraph'' is used as a balance to indicate whether the feeder is living up to its machine layout. Further application of this method of control is used to balance the production of other parts needed.

784 The charts that are used in this scheme of production control are hung in the sections where the work is being carried on. As a bonus is paid on actual production in comparison with the task and the delivery efficiency of a section, these diagrams act as a barometer for the foremen and their assistants. The scales of the chart can be expressed in pounds, tons, pieces, or any other unit of productive activity.

Section IV

MANAGERIAL FEATURES OF GRAPHIC PRODUCTION CONTROL

Chapter XXII

GRAPHIC PRESENTATION OF EXECUTIVE INFORMATION

785 In the author's experience it is a rare case, indeed, to find an executive who is in receipt of prompt, comprehensive, simple and adequate presentations of statistical information. In only a few of these rare cases have the presentations been graphic in nature to the extent possible.

786 Everything that has been said regarding graphics in controlling production applies to the matter of the executive control of a business, and it is our firm conviction that one of the greatest fields awaiting the development of the management engineer is the proper graphic presentation of executive information.

787 Not only has business become more complex and difficult, but the average executive is absorbed in so many interests that he has no time for elaborate compilations of facts and statistics. Not taking the time, he does not digest them, and as a result they are valueless to him from the standpoint of the purpose for which they were intended, namely, to facilitate executive thought and action.

788 Further, executives are more and more desirous of knowing future tendencies, predeterminations, things likely to happen and in anticipation, than ever before, and dry and uninteresting arrays of figures are not suited to rapid-fire action in these respects. The big men in industry, men who are on many boards of directors, are the ones regarding whom the above is especially true.

789 In Graphic Production Control, the matter of an official tie-up of all phases of the work, the matter of clearing all pertinent data through a single function so as to

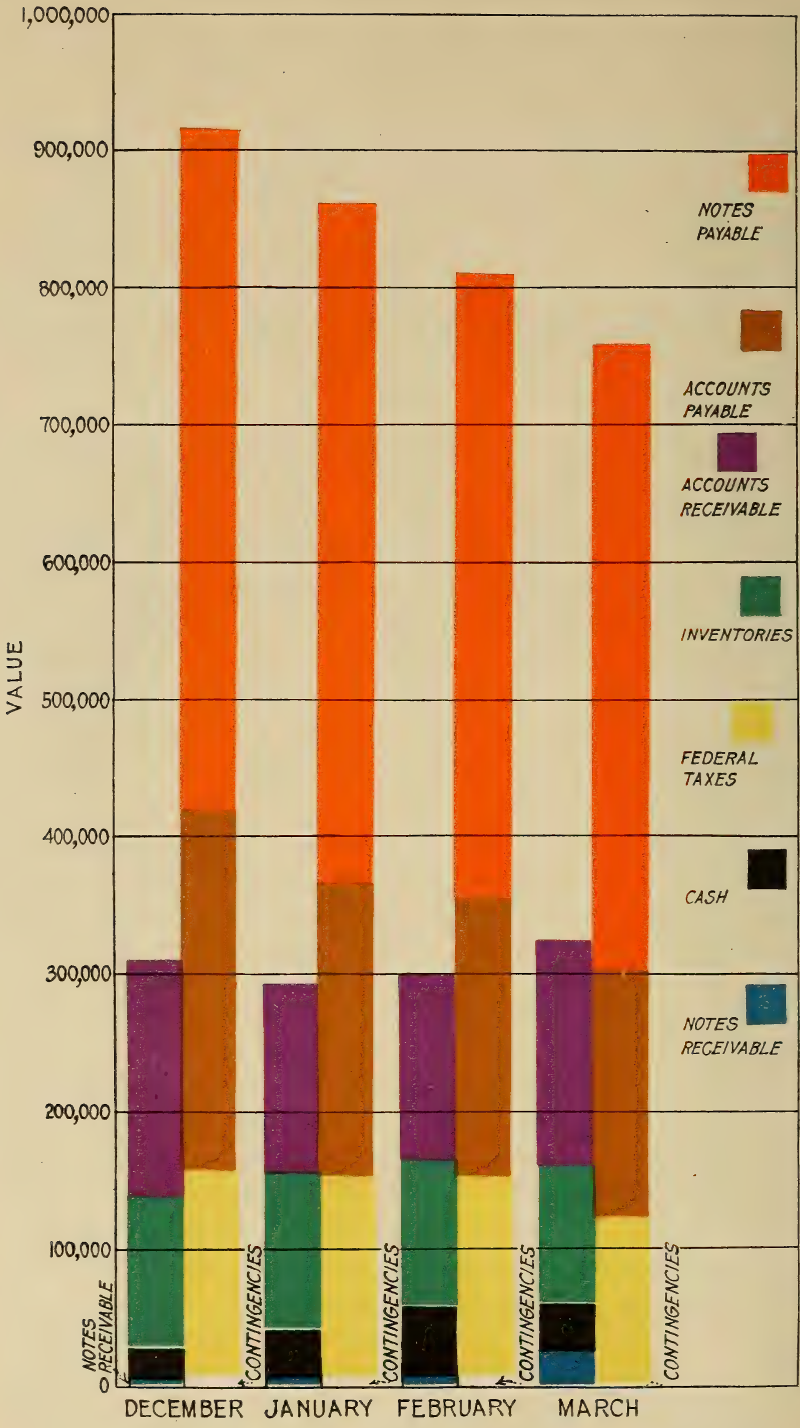


FIGURE 125. COMPARISON OF CURRENT ASSETS AND LIABILITIES

assist the management, the matter of whether or not the production methods are getting results, are of sufficient importance to warrant a chapter being devoted to ''Graphics for the Executive.''

790 On the industrial executive rests an enormous responsibility to-day. On his deliberations and decisions depends our future industrial success. If his decisions are based on improper data, improperly presented, he will do justice neither to himself nor to the problems confronting him. If based on the right kind of information, graphically shown, he is in a much better position to reason wisely and well, and to decide quickly and logically.

791 In addition to all this, graphic presentation for the executive is a conservation measure, for it is a known fact that the use of graphics reduces executive fatigue; and as absence of, or reduced, fatigue makes a man all the stronger and better, graphic mechanisms are entitled to more than the usual amount of attention.

792 No single chapter could begin to exhaust the possibilities as to the use of graphics for the executive. The best plan to follow is to reproduce a number of charts, made up in different ways, to give an idea regarding what to show and how to show it. We will call these ''managerial charts,'' to distinguish them from the production charts of the Control Department.

793 Of first importance to an executive is the matter of financial condition. Figure 125 shows a comparison between current assets and liabilities. The assets and liabilities are shown side by side for each month, and then according to months. By the use of colors the comparisons are facilitated, and, as can be seen, the chart is an excellent one for the busy executive.

Figure 126 illustrates a comparison of total assets and liabilities, in which both colors and different kinds of cross-hatchings are used to distinguish the various factors entering into the assets and liabilities. The chart is made up according to months.

794 Knowing his financial condition, the executive is next interested in the matter of the efficiency of his operations. He wants to know, first of all, the relation between

the capacity, scheduled production and actual production, in terms of standard units of production. In Figure 127

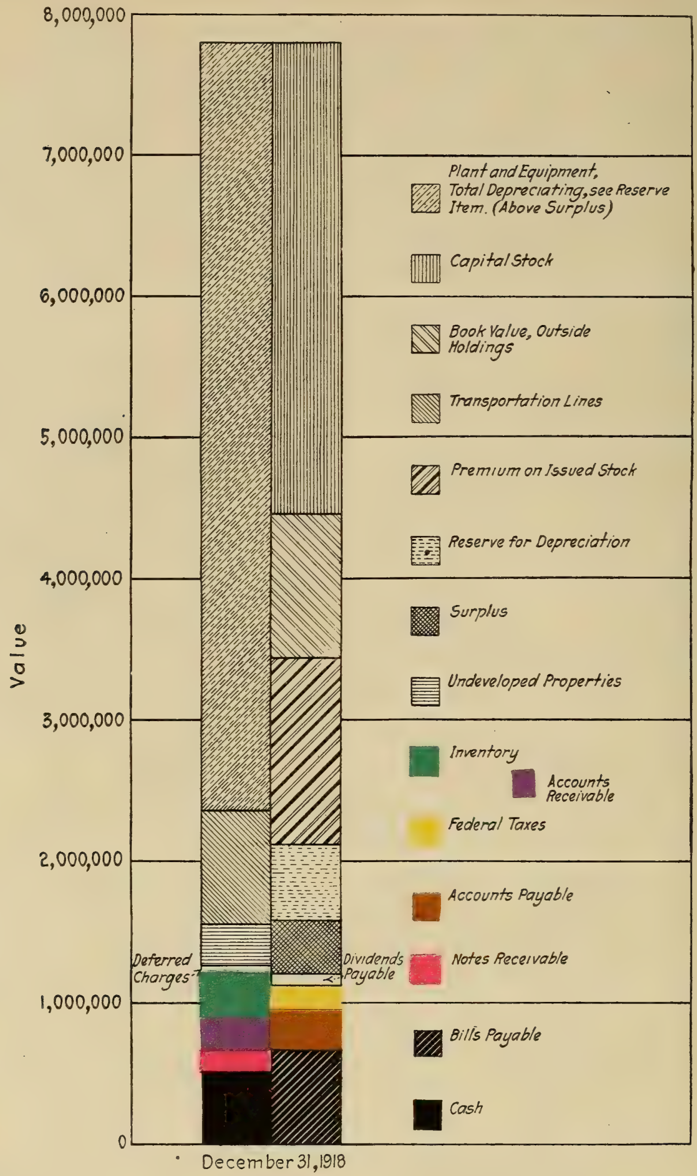


FIGURE 126. COMPARISON OF TOTAL ASSETS AND LIABILITIES

these elements have been plotted as shown. The information which can be gathered from this chart is as follows:

1 The standard capacity of the plant, division or department is shown by the line A.

2 The production which may be expected at present efficiency if the plant, division or department is run to capacity, and its relation to standard capacity, are shown by the line B.

3 The scheduled production and its relation to standard capacity production and to capacity production at

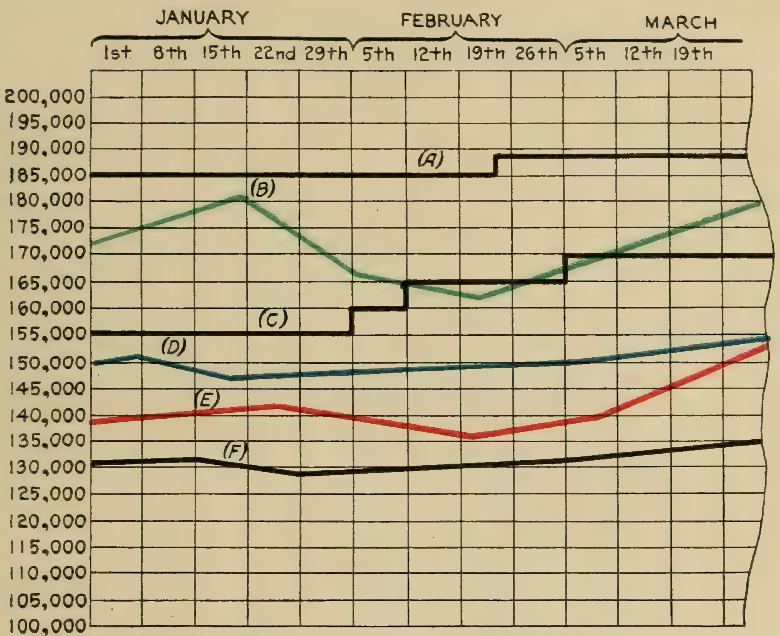


FIGURE 127. RELATION BETWEEN CAPACITY SCHEDULE AND ACTUAL PRODUCTION

present efficiency are shown by the line C and its comparison with lines A and B.

4 The amount the plant, division or department would have fallen short of scheduled output if it had worked the full scheduled hours at the present rate of efficiency is shown by the line D and its comparison with the line C.

5 The output which should have been produced in the hours worked, the output which actually was produced, and the loss due to inefficient work are shown by the lines E and F and their comparison.

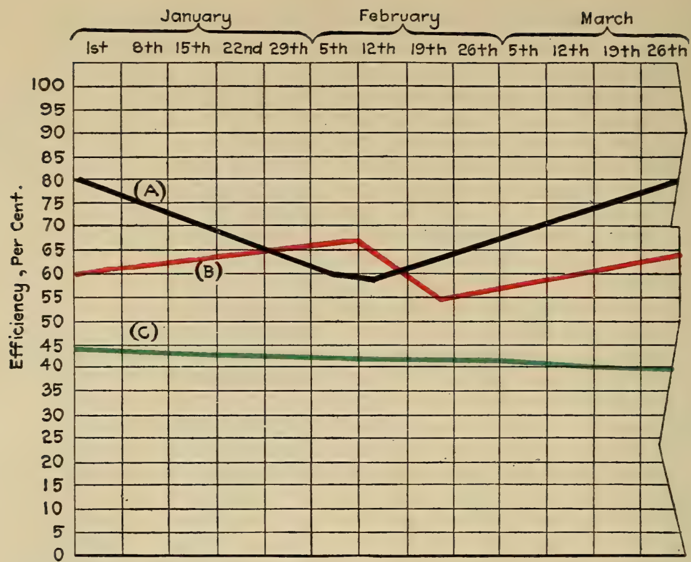


FIGURE 128. PERCENTAGE RELATION BETWEEN CAPACITY SCHEDULE AND ACTUAL PRODUCTION

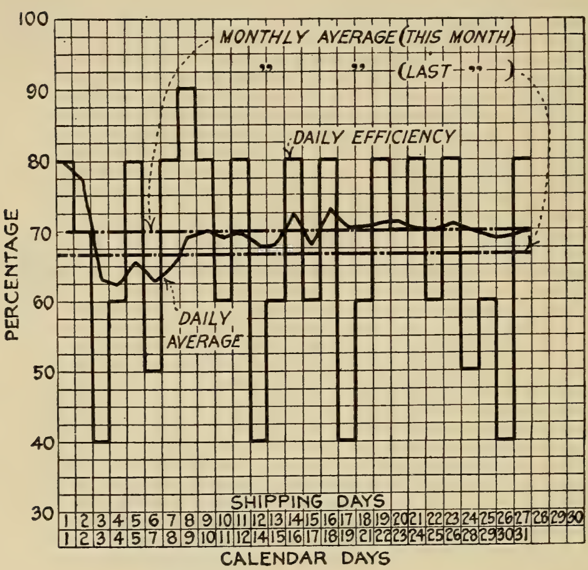


FIGURE 129. PLOTTING OF EFFICIENCY OF DELIVERIES

6 The extent of the failure to meet the schedule is shown by a comparison of the lines F and C.

7 The extent which the actual quantity produced falls

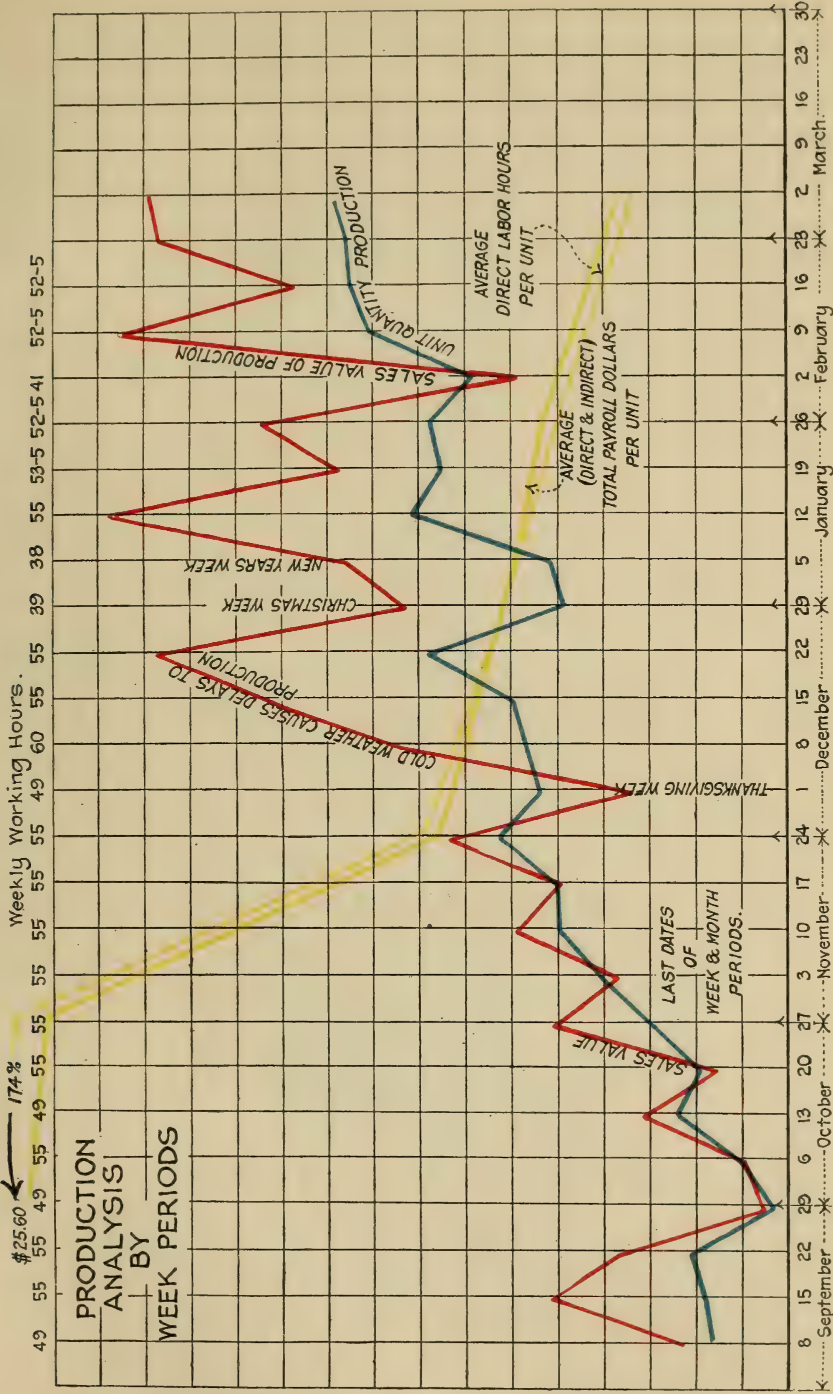


FIGURE 130. RELATION OF PRODUCTION AND COSTS

below the standard capacity of the plant, division or department is shown by a comparison of the lines F and A.

795 To give the executive the efficiency in percentage, Figure 128 is submitted, as follows:

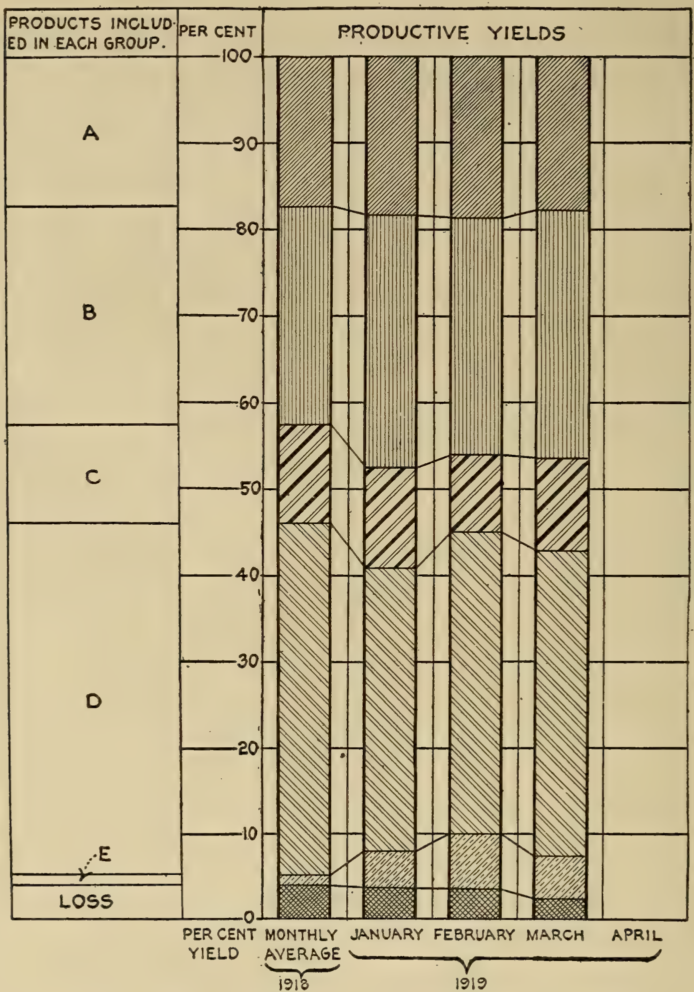


FIGURE 131. PRODUCTION PLOTTED BY PRODUCTS

1 The efficiency of the work done, the tendency to improve, and the extent to which production may be increased through improved efficiency are shown by the line A.

2 The efficiency in meeting the schedule, the ten-

dency to improve, and the extent to which the working force would have to be increased to meet the schedule at the present rate of efficiency are shown by the line B.

3 The relation of the production obtained to the capacity of the plant, and the increase in production which would be possible by the use of all equipment at the standard rate of production, are shown by the line C.

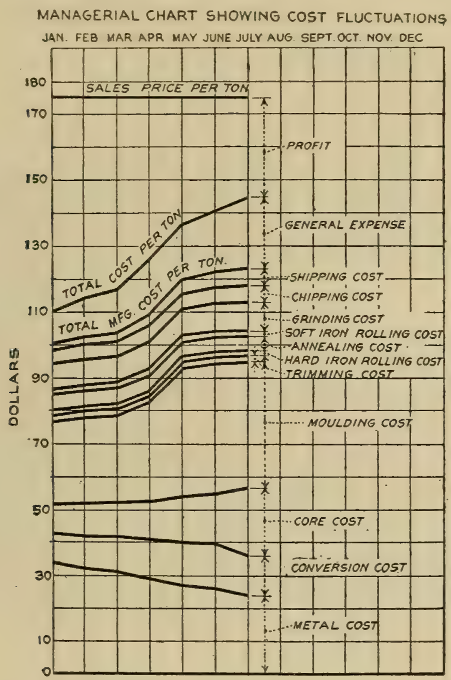


FIGURE 132. COMPARISON OF COSTS ACCORDING TO ELEMENTS

796 Another form of showing efficiency is shown at Figure 129, which is self-explanatory.

797 The executive next desires information as to production and costs. Figure 130 is a valuable one to him in this respect, in that it shows—

A Unit quantity of production—full blue line.

B Sales value of production—red line.

C Direct and indirect payroll cost per unit—heavy yellow line.

D Direct labor hours per unit—dotted yellow line.

798 Figure 131 illustrates an excellent means of showing graphically the different production yields or the products made. Not only are the months compared, but there is a comparison against the monthly average for the previous year.

799 Figure 132 is the same kind of a chart as Figure 131, except that costs are considered instead of production.

800 Knowing about the financial condition, costs and production, the executive now desires to go more into de-

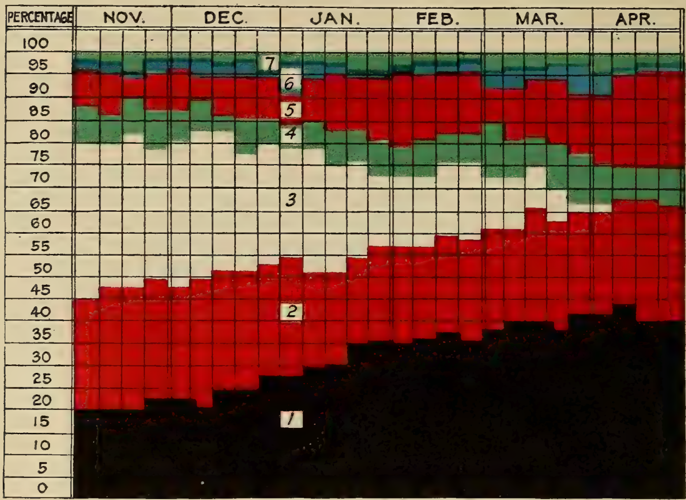


FIGURE 133. PERCENTAGE USE OF EQUIPMENT

tails as to the pertinent information with reference to his plant operations.

801 The first important consideration is the use of equipment, and Figure 133 illustrates a means of providing a manager with a chart covering the entire plant, showing a complete analysis of equipment. The information shown is as follows:

A The actual machine production obtained, and its comparison to the total standard machine capacity, is shown by area 1.

B The loss of production through inefficient opera-

tion and its relation to the work actually produced, are shown by area 1 and a comparison of areas 1 and 2.

C The loss of production due to low sales is shown by area 3.

D The equipment idle because of lack of operators,

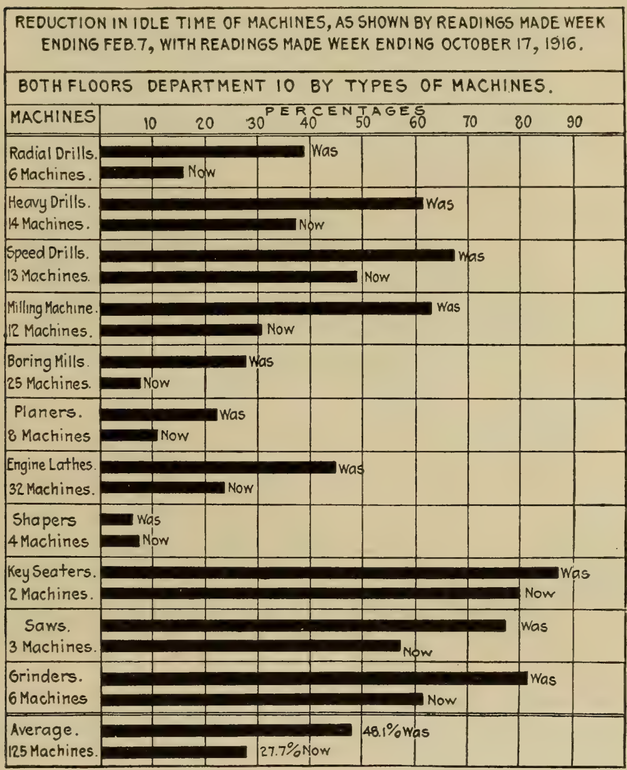


FIGURE 134. COMPARISON OF IDLE TIME

for which the Employment Department is responsible, is shown by area 4.

E The loss of production due to waiting for materials, caused by poor planning, purchasing, or stock-keeping, is shown by area 5.

F The loss of production through idle time for repairs, for which the Engineering Department is responsible, is shown by area 6.

G The possibility of increasing the production from

the equipment through corrective action is shown by the area of each chart item, and the results obtained by such corrective action will be clearly shown on the chart.

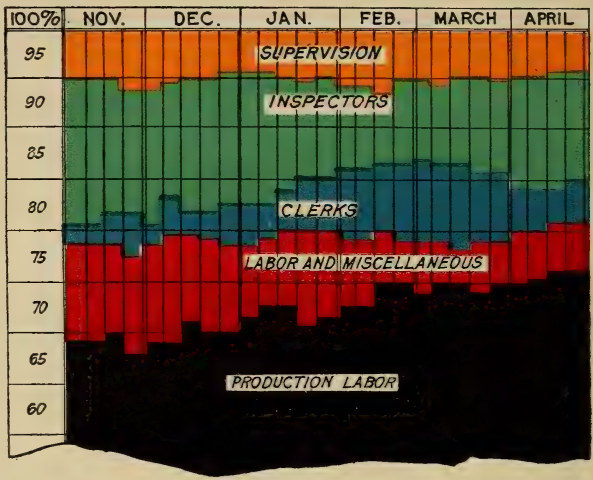


FIGURE 135. PERCENTAGE COMPARISON OF CLASSES OF LABOR

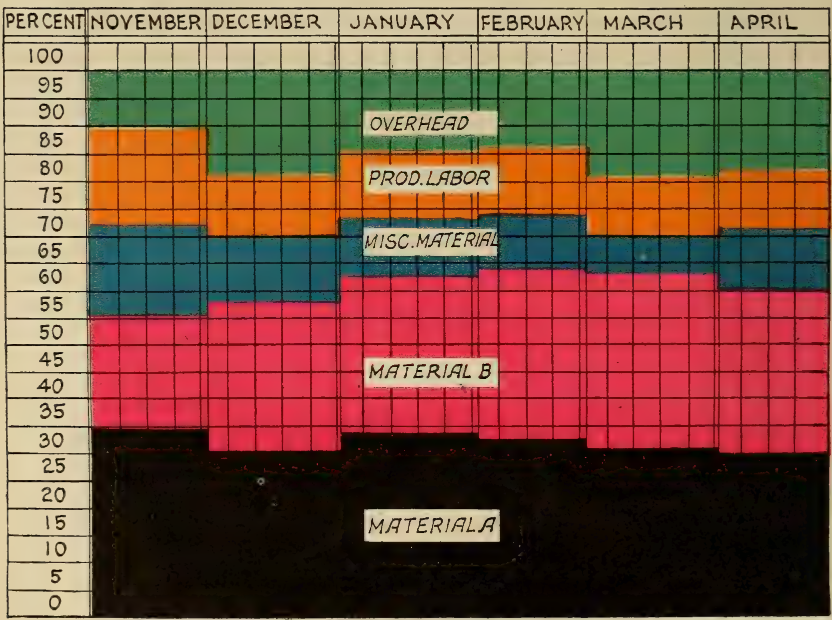


FIGURE 136. PERCENTAGE COMPARISON OF MAIN SUB-DIVISION OF COSTS

802 By the heavy black bar method of charting, Figure 134 illustrates a means of periodically comparing results or gains or losses, as (in this case) the reduction of idle time of equipment.

803 The executive, knowing about his equipment, now desires information regarding the labor element, and this is graphically presented in Figure 135. To give him a general conception of the main factors comprising the cost of the product, variations over periods of time and the effects of such variations on the cost of the standard product, Figures 136 and 137 are submitted, which show—

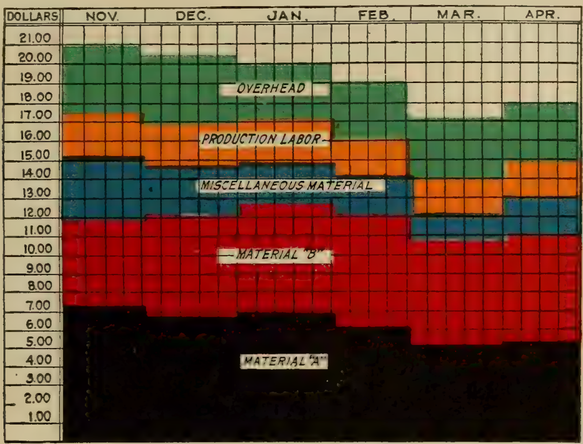


FIGURE 137. COMPARISON OF MAIN SUB-DIVISION OF COSTS ON A DOLLAR BASIS

804 AS TO FIGURE 136:

A The percentage of total cost of materials, productive labor and overhead.

B The proportion between the various costs.

C The tendency of each item to increase or decrease.

805 AS TO FIGURE 137:

A The variation in the cost of the standard unit of production.

B The variation in the main items making up that cost.

C The dollars per standard unit cost of the main expense items.

D The proportion between the various items of cost.

806 Figures 138 and 139 are prepared to give the executive a conception of the relation of the payroll of each division to the total payroll, the relations between the payroll of all divisions, the tendencies of the payroll to increase or decrease, and the relation of the payroll of each division to the cost of the standard unit of product.

807 Figure 140 illustrates the manner of showing graphically a business as a whole, so as to be able to tell where losses end and profits begin. There are naturally some costs which must be met, whether there is any work

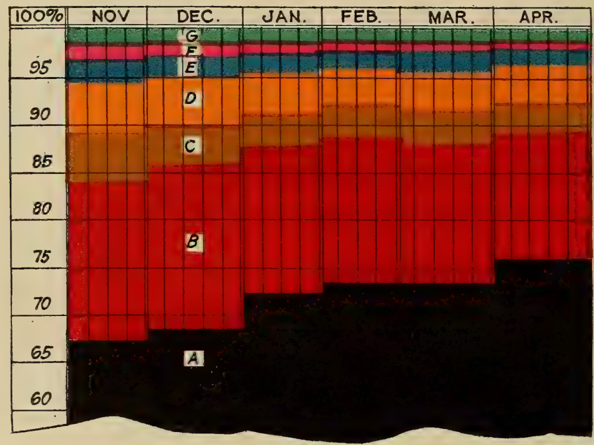


FIGURE 138. PERCENTAGE COMPARISON OF DIVISIONS OF A BUSINESS

done or not. In other words, cost does not begin at zero, but at a point which represents fixed expenses, whether the plant operates or not. When goods are being produced, costs are plotted from this point. By plotting sales from zero, the costs and sales lines will cross at some point, to the left of which there will be losses, and to the right, profits. By plotting actual figures and capacity against these lines some valuable information can be secured.

808 Control boards can be used by the executive if he desires to go further into the use of graphics than is indicated by the figures illustrated in this chapter. Control boards can have departments or products down the sides and dates across the top, and show the condition of the

plant at a glance. Figure 141 illustrates a standard type of control board which can be used to advantage, and which shows such information as the following:

A Amount of material ahead of each department or product and the length of time material will keep the department or product operating.

B The material received to date, in comparison with the material scheduled to be received.

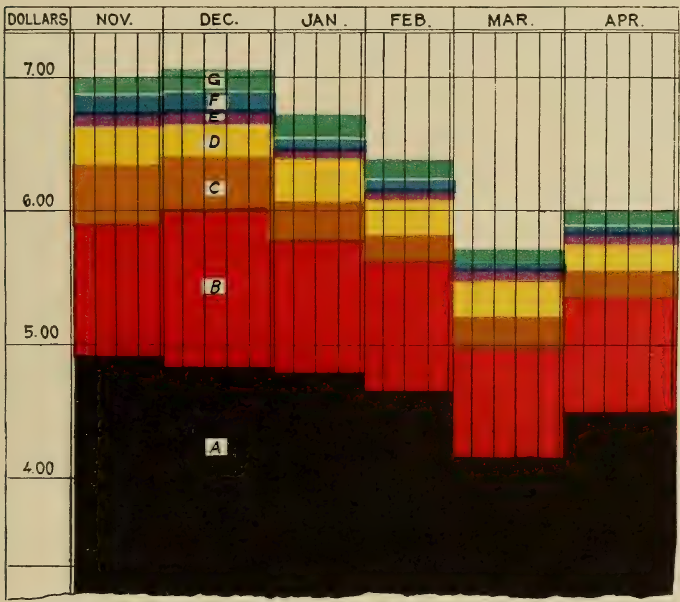


FIGURE 139. COMPARISON OF DIVISIONS OF A BUSINESS ON A DOLLAR BASIS

C The production completion by department, or product, and its comparison with the schedule.

D Conditions which are liable to interrupt and decrease production.

E To what extent the departments or products are out of balance as to material or labor effort.

809 As can be seen, a board such as described would give the executive a comprehensive and vivid picture of the immediate condition of the various departments or products.

810 As regards method of operation, each department is represented on the board, for the time scheduled ahead, by a strip of cardboard. The strip is usually set in a narrow pocket extending the length of the board, with the top edge projecting above the pocket.

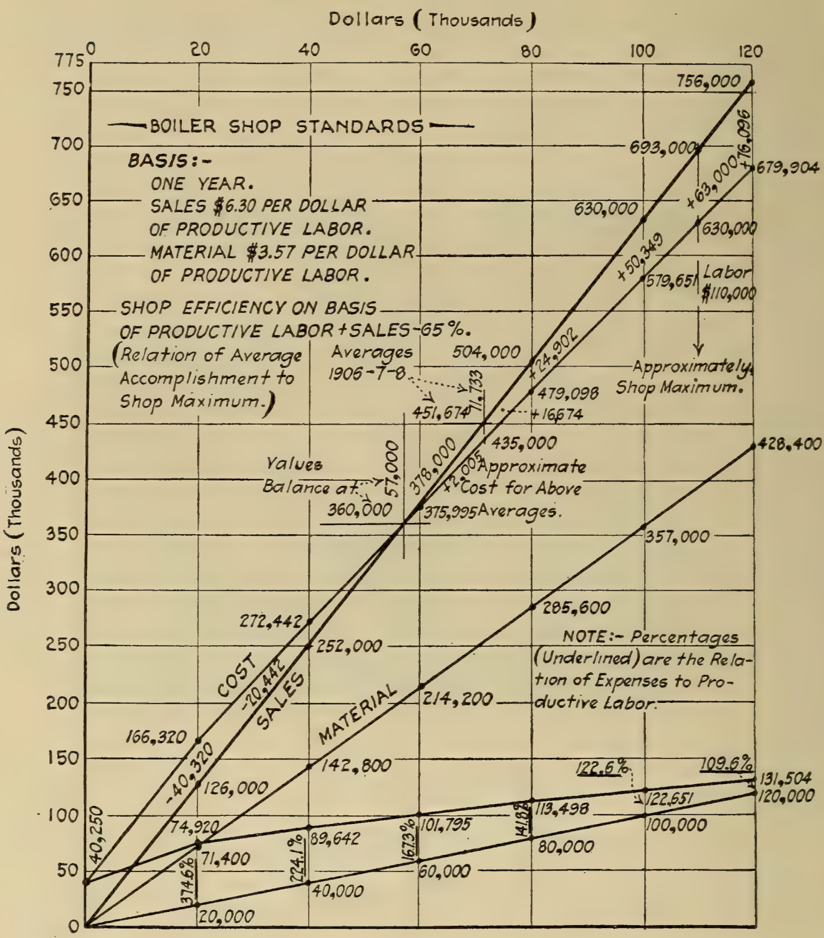


FIGURE 140. SHOP STANDARDS AT DIFFERENT CAPACITIES

811 When a schedule is set, a strip of cardboard, cut to a length representing to board scale the number of days covered by the schedule, is inserted on the board under the dates which the schedule covers.

812 The number of man hours of work required per de-

partment hour in order to meet the schedule is now calculated and entered on the strips. This calculation consists of multiplying the scheduled production per hour of each size or product by the product hours required to produce

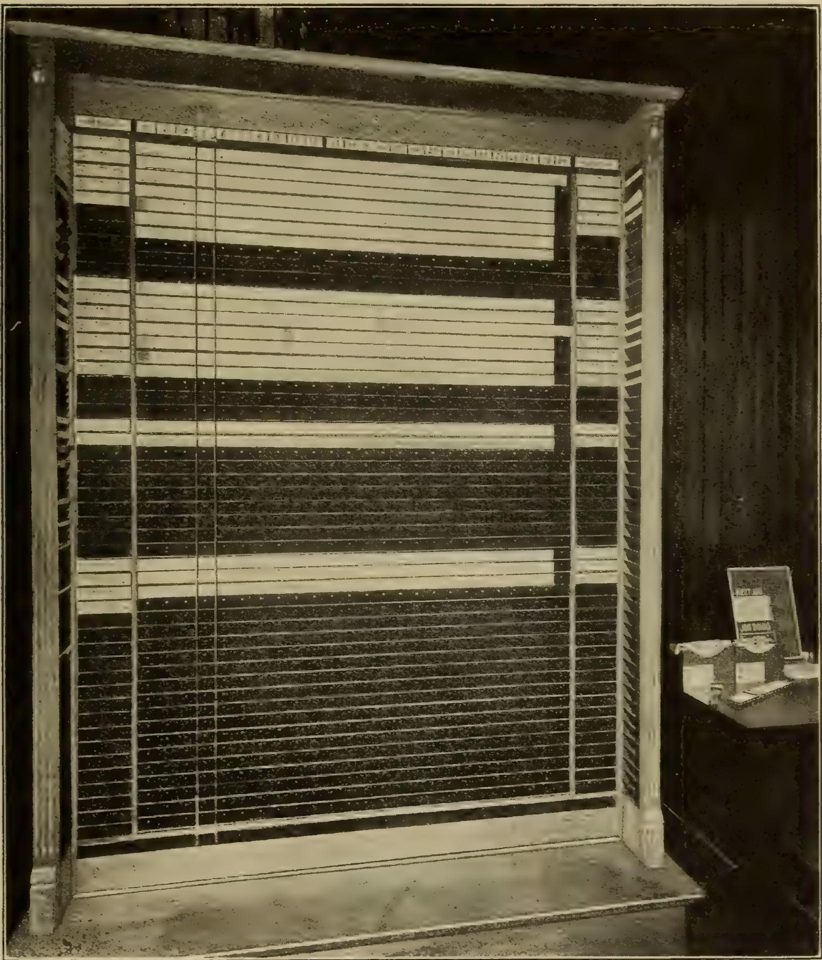


FIGURE 141. AN EXECUTIVE'S CONTROL BOARD

same, and totaling the results. The number of standard units of production which this number of hours represents is calculated and also entered on the strip.

813 When material is received in the department it is converted into terms of the standard units of production

it will produce. The departmental hours of work, corresponding to the standard units the material will produce, are then marked off on the control board by drawing a green line on the strip representing the department, through the number of hours released.

814 As the product released is limited by that one of the materials needed of which the least quantity is on hand, the hours released, as shown by the shortest material line, are entered as work released on the divisional control board.

815 As work is completed in the department, the number of department hours it represents is entered on the divisional control board by covering the green "material line" with black for the number of standard departmental hours completed.

816 In closing, a brief outline of some of the reports which can be graphically illustrated to advantage may prove of value, and is as follows:

Overtime.
Spoiled and defective work.
Non-productive and productive labor.
Labor turnover.
Accidents.
Bonus.
Inspections.
Maintenance costs.
Work in process.
Orders on hand.
Idle time of men paid for.
Idle time of equipment.
Shipments.
Purchases.

817 It is hoped that the proper amount of thought will be devoted to this chapter, as the author is satisfied that it would convince an executive as regards the value and importance of graphical presentation in his every-day work.

CHAPTER XXIII

GRAPHIC PRODUCTION CONTROL IN ITS RELATION TO ORGANIZATION

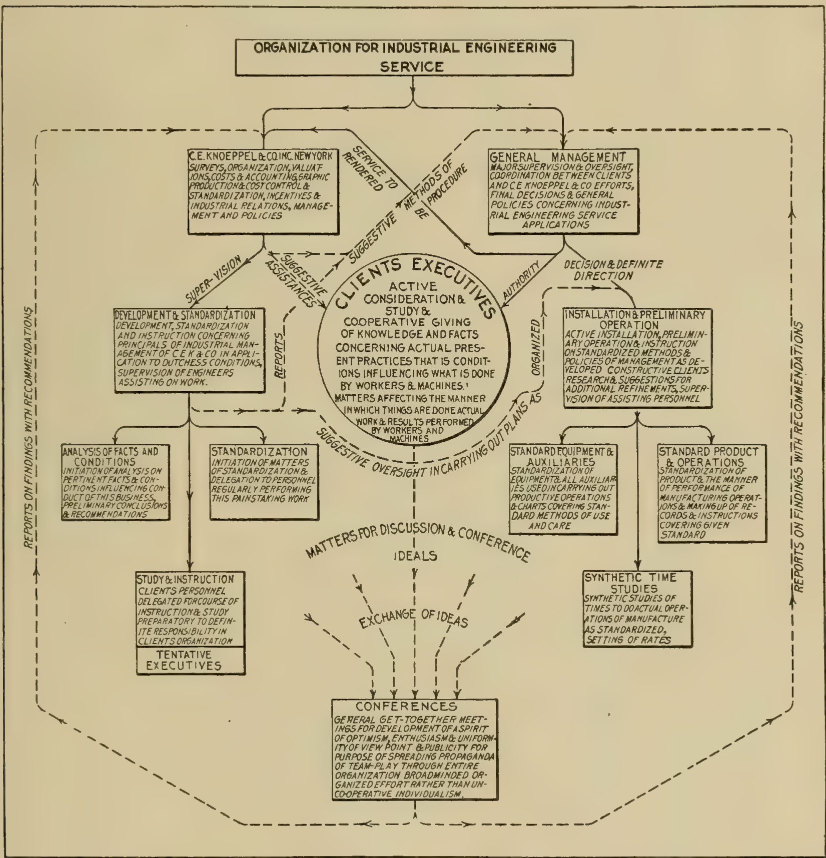


FIGURE 142. ORGANIZATION CHART FOR INDUSTRIAL ENGINEERING SERVICE

818 Organization can be defined as "The process of dividing a complex objective into minor activities each of which is well within the scope of individual effort."

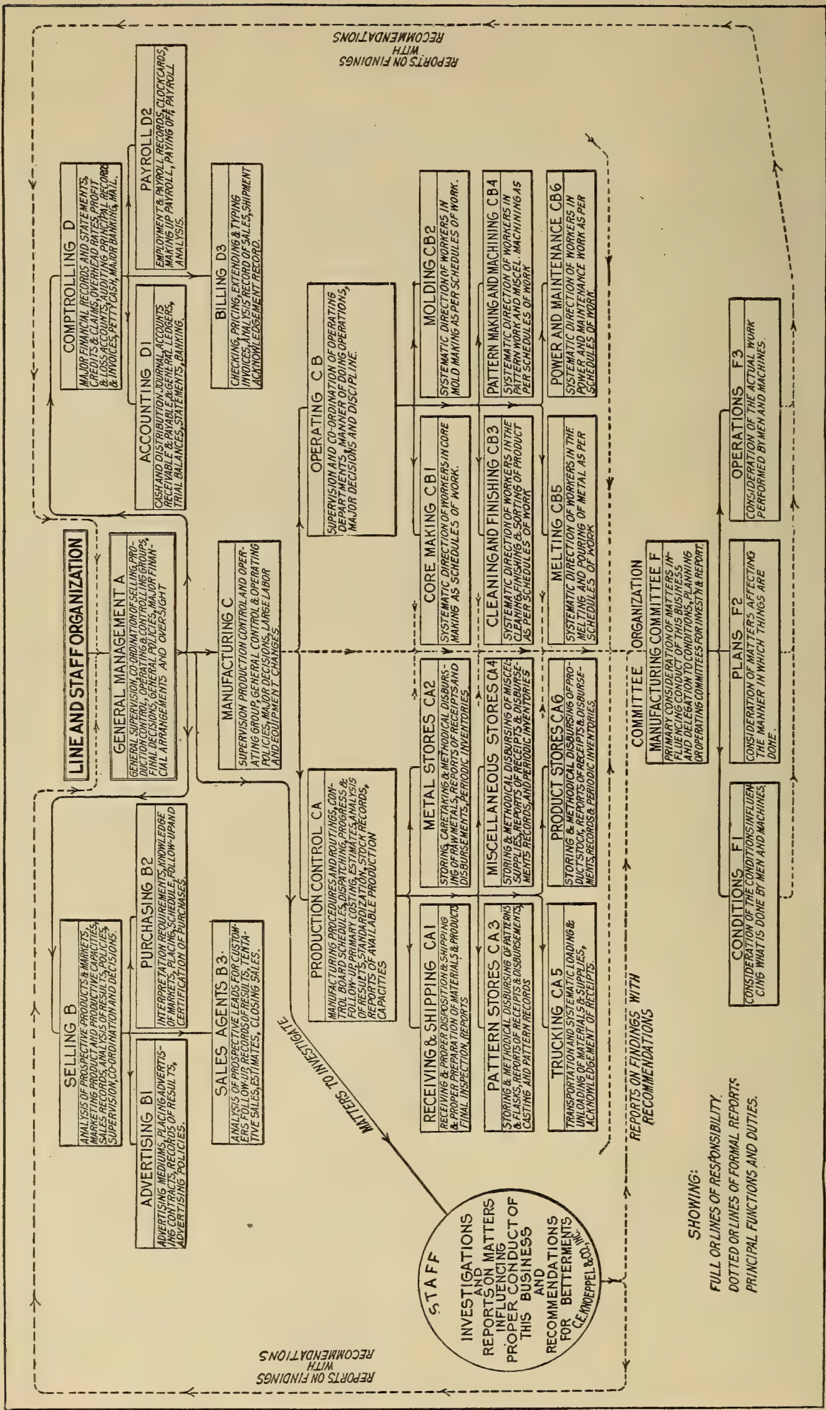


FIGURE 143. LINE AND STAFF ORGANIZATION CHART

819 Industrial management is so much more complex to-day than it was fifty or a hundred years ago that the matter of coördination must be as carefully considered as that of running freight and passenger trains in both directions over the same tracks.

820 There is a direct relationship between organization and Graphic Production Control. Obviously, we are in

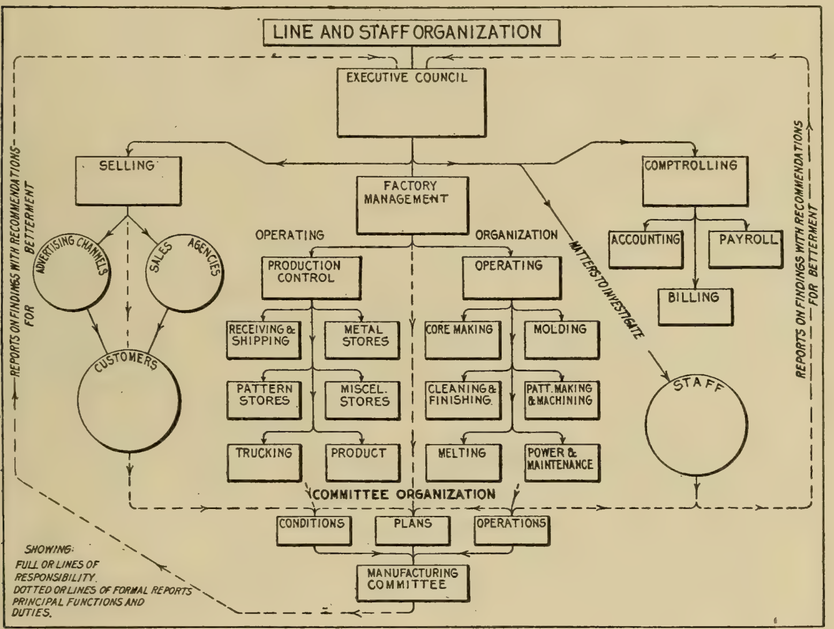


FIGURE 144. LINE AND STAFF ORGANIZATION CHART

business to produce goods, and production means more to the world to-day than ever before. To produce efficiently, we must control production along the most scientific lines, and to do this there must be the best possible coördination of the many and diversified activities. There can be no production control without organization, hence the statement that *production control forces organization.* It does this, however, in an evolutionary way rather than through revolutionary tactics.

821 If the methods of Graphic Production Control reveal troubles in the material side of the business, this

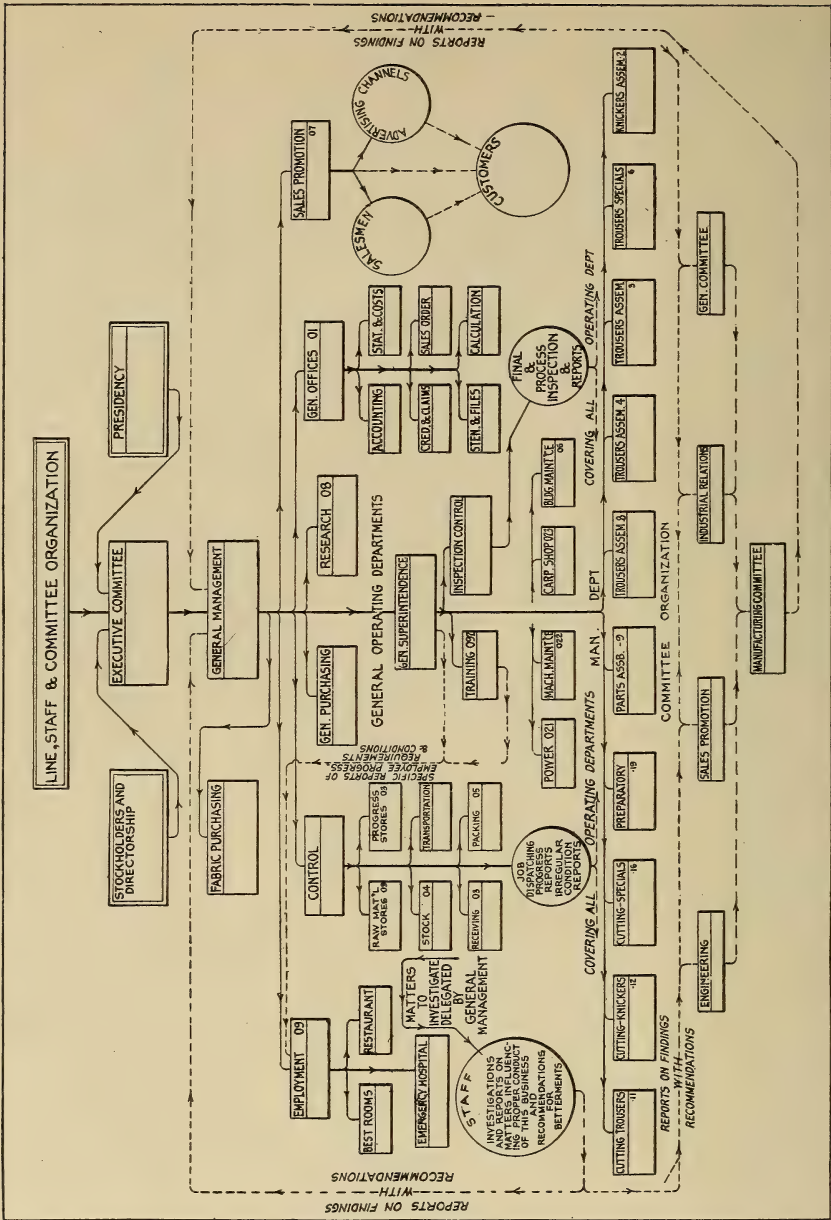


Figure 145. Line and Staff Organization Chart

phase of the work must be organized to eliminate the troubles. If the labor end is found to be loosely handled, organization steps in to correct the difficulties. If no efforts

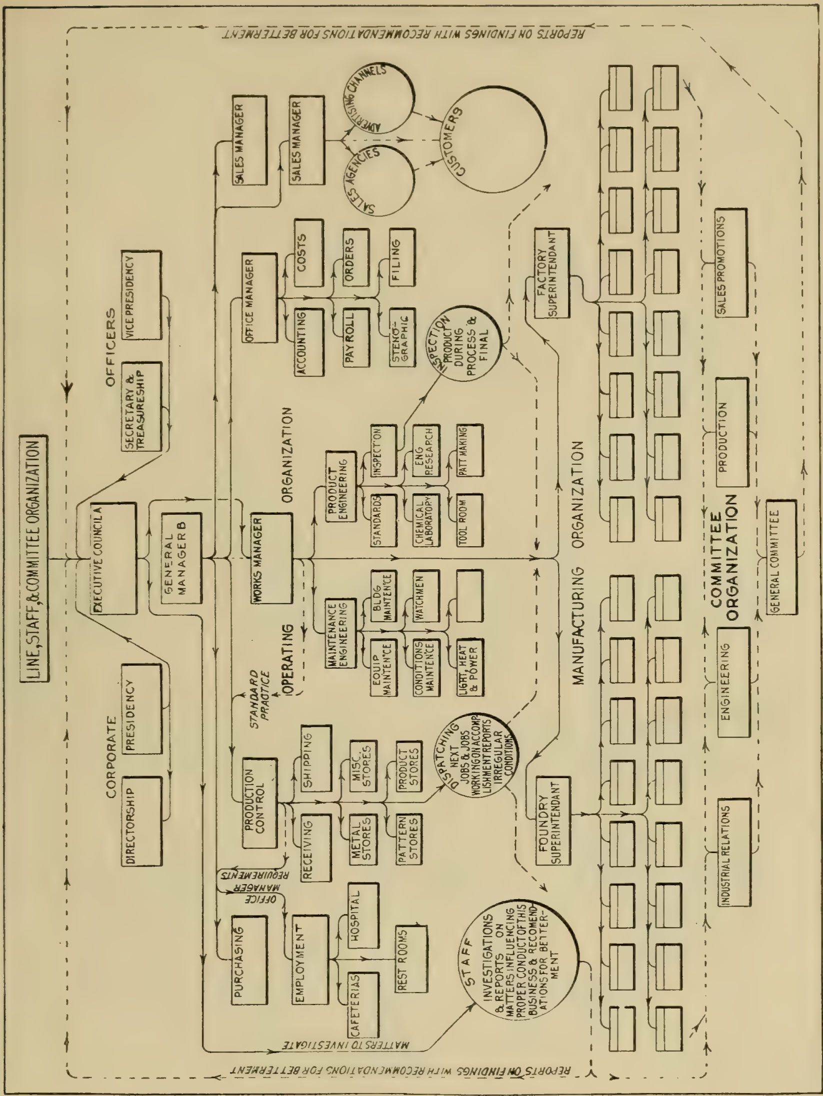


FIGURE 146. LINE AND STAFF ORGANIZATION CHART

are made to watch idle equipment and to anticipate breakdowns, then the work must be organized. If knowledge as to product is not forthcoming either when it should or in the way it should, then it is the function of organization to arrange for better procedure.

822 To coördinate the material, product, labor and the

equipment factors, organization is a prime requisite. If we are to get the greatest amount of efficiency out of the production side of business as a whole, all the elements must be

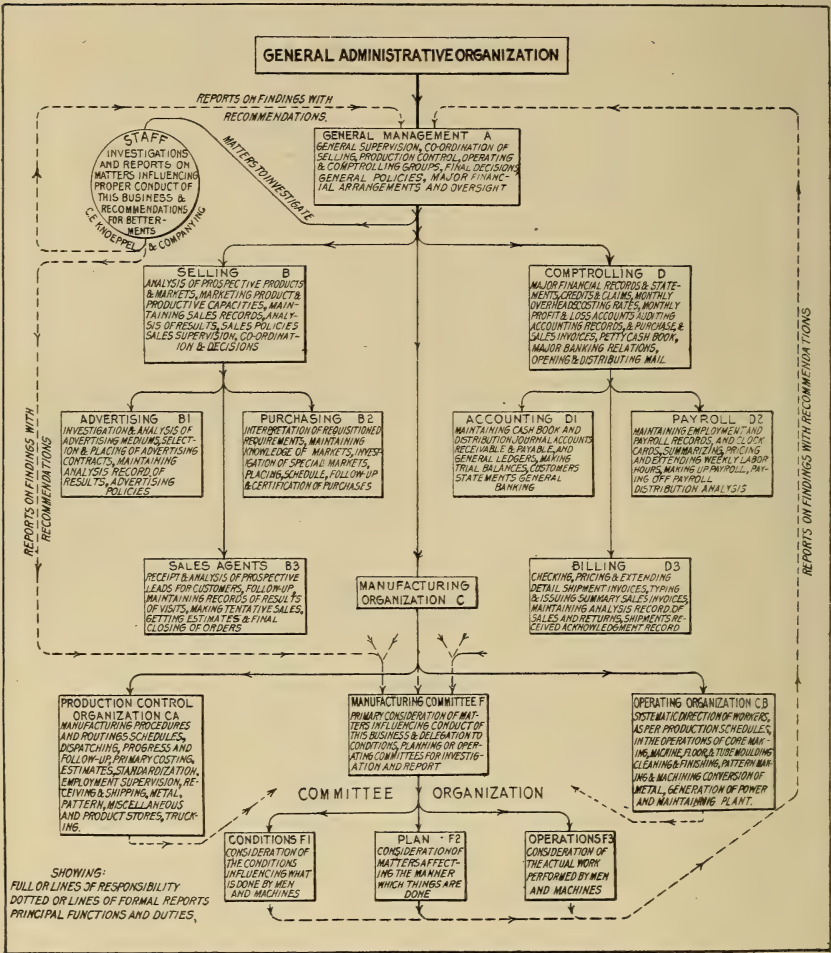


FIGURE 147. GENERAL ADMINISTRATIVE ORGANIZATION CHART

properly related and allowed to function to best advantage.

823 Organization is a matter of definite laws controlling it, which are:

A OBJECTIVE. Working up a tentative plan with reference to the ultimate development desired.

B Greatest Complication. The determination of the most complicated phases of the objective.

C Concentration. Placing in each division of a business all of the factors which effect the performance of its own function.

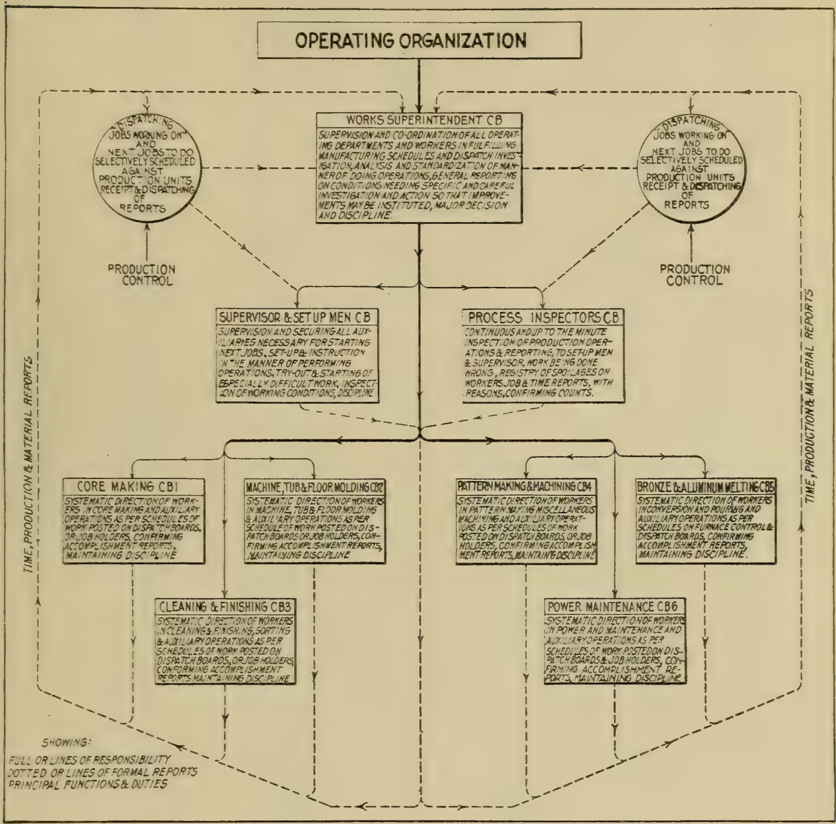


Figure 148. Operating Organization Chart

D Individualism. Placing in the hands of one man, most competent to handle the work, one or more functions of a business.

E Mental Capacity. Dividing work in an organization with reference to the knowledge and ability that will be required of a man in charge of one or more functions of a business.

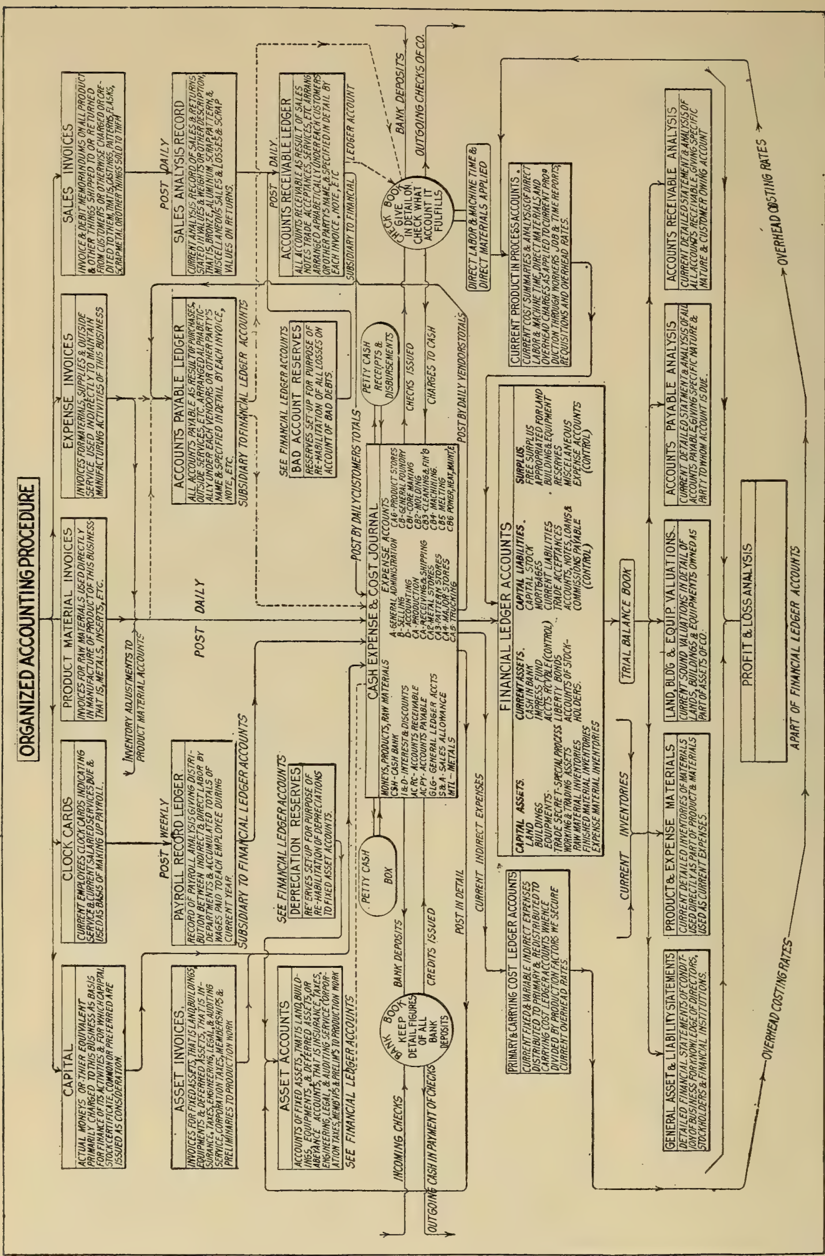


FIGURE 149. ORGANIZED ACCOUNTING PROCEDURE

F SPECIALIZATION. Dividing work so that a man may operate in limited fields rather than cover many diversified

fields, in order that a few things may be done well rather than a large number superficially.

G Responsibility. Holding a man responsible for the total proved results that he secures in his division, and not

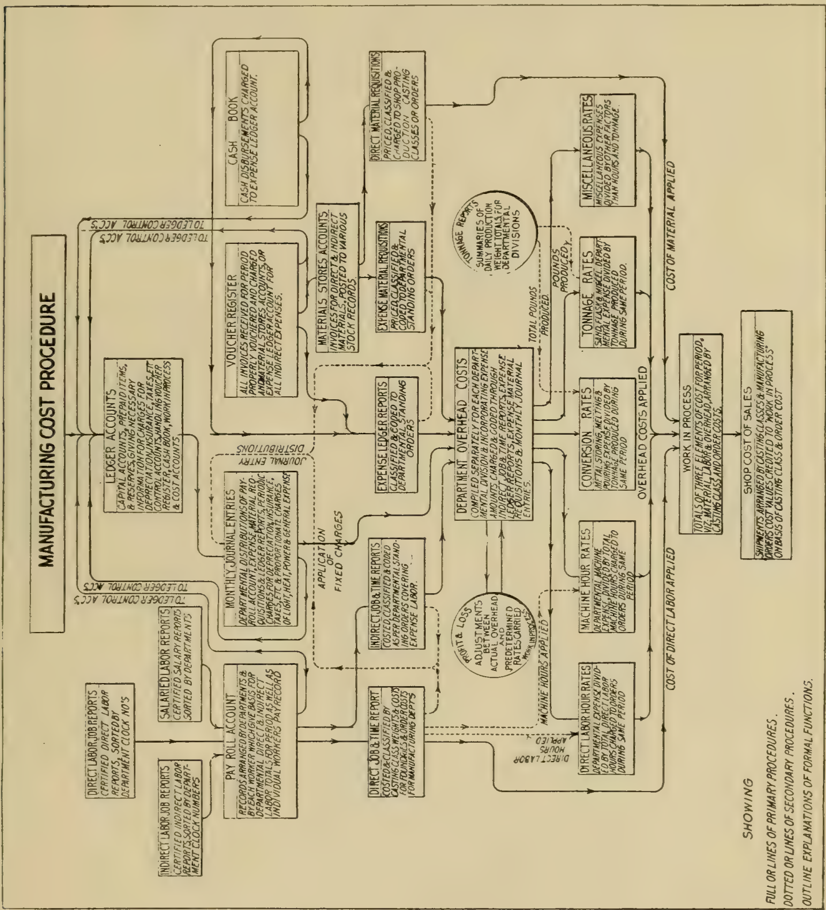


Figure 150. Manufacturing Cost Procedure

for the details or the methods that he uses in securing these results.

H Permanency. Training men to fill other positions than their own, and providing for understudies so that changes in an organization may easily be made without disruption.

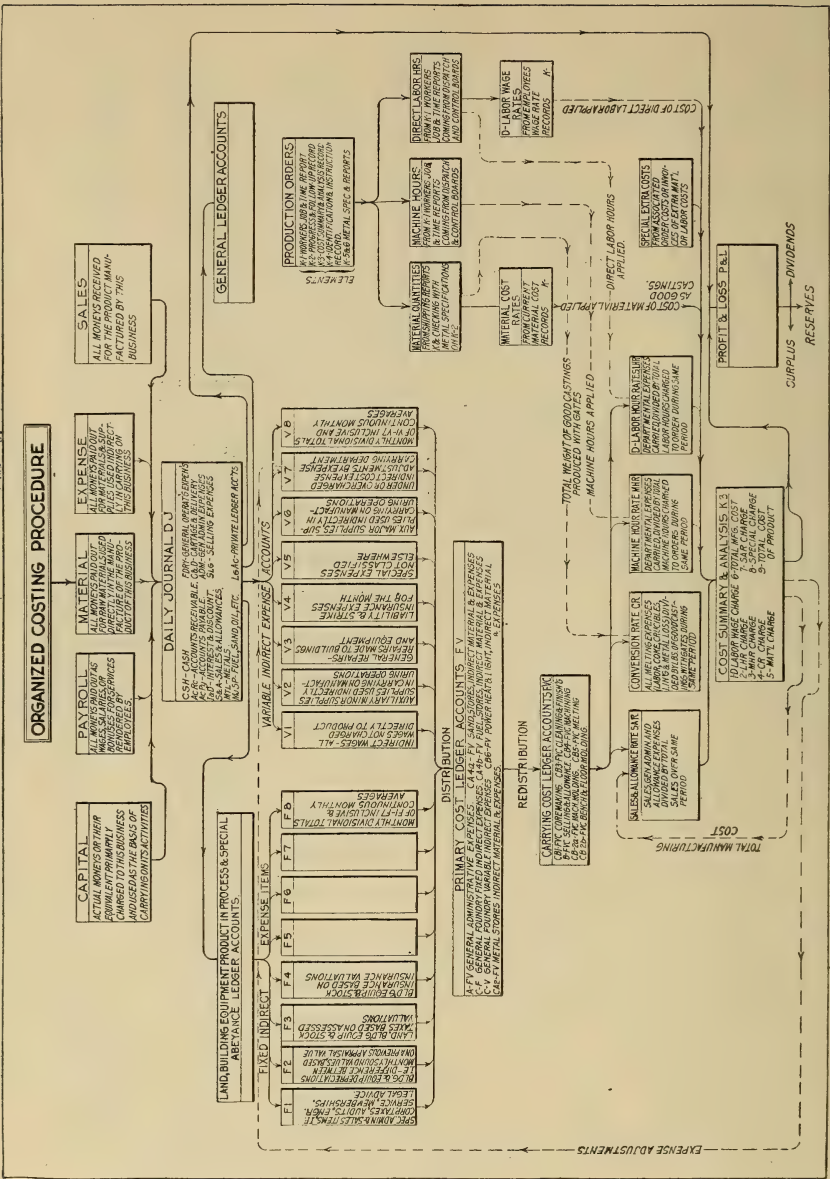


FIGURE 151. ORGANIZED COSTING PROCEDURE

I CROSS-FERTILIZATION. Giving each pivotal man in an organization some opportunity during the year to know the methods of the departments his work influences mostly, and of the departments which influence his work.

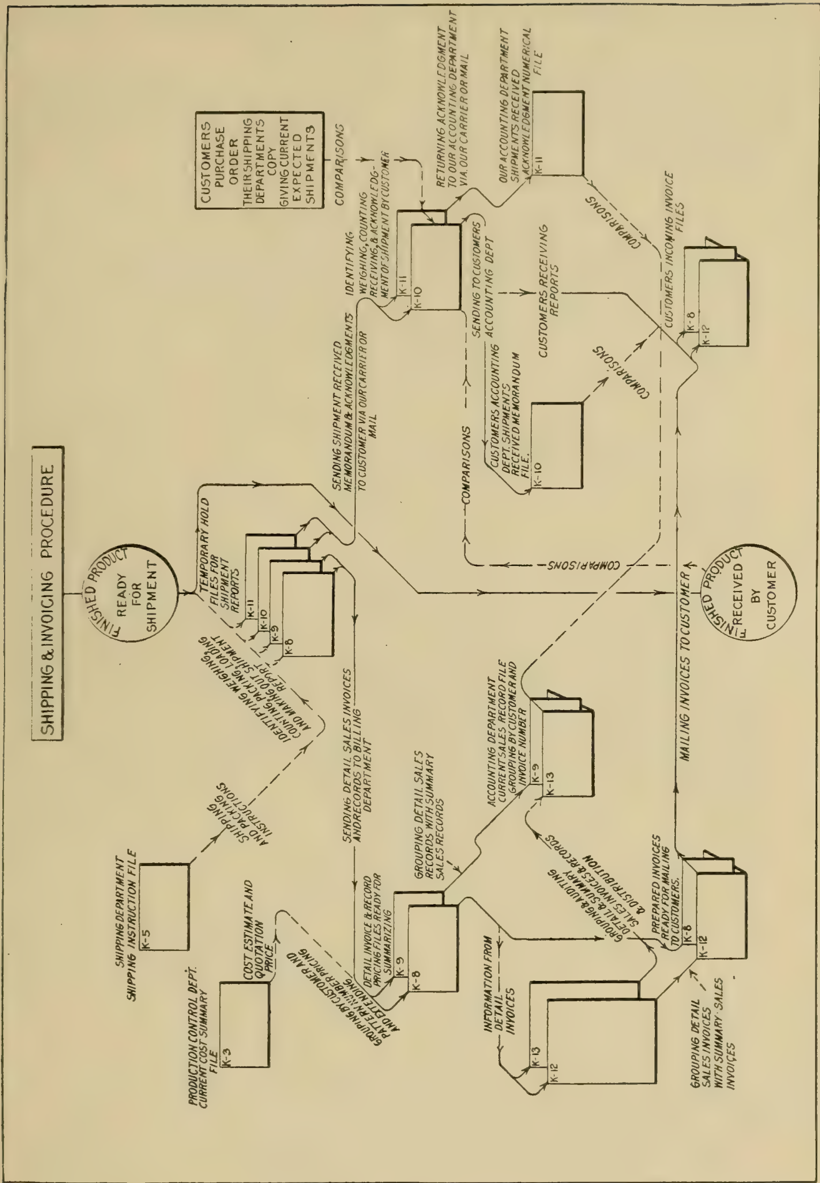


FIGURE 152. SHIPPING AND INVOICING PROCEDURE

J RELATIONSHIP AND INSTRUCTION. Providing a man with a clear-cut conception of the relationship existing between himself and those he is associated with, as well as with a

written outline of duties, functions, responsibilities, results expected and methods affecting his work.

K PERSONNEL. Analyzing the requirements of given positions and finding men whose qualifications match the given requirements.

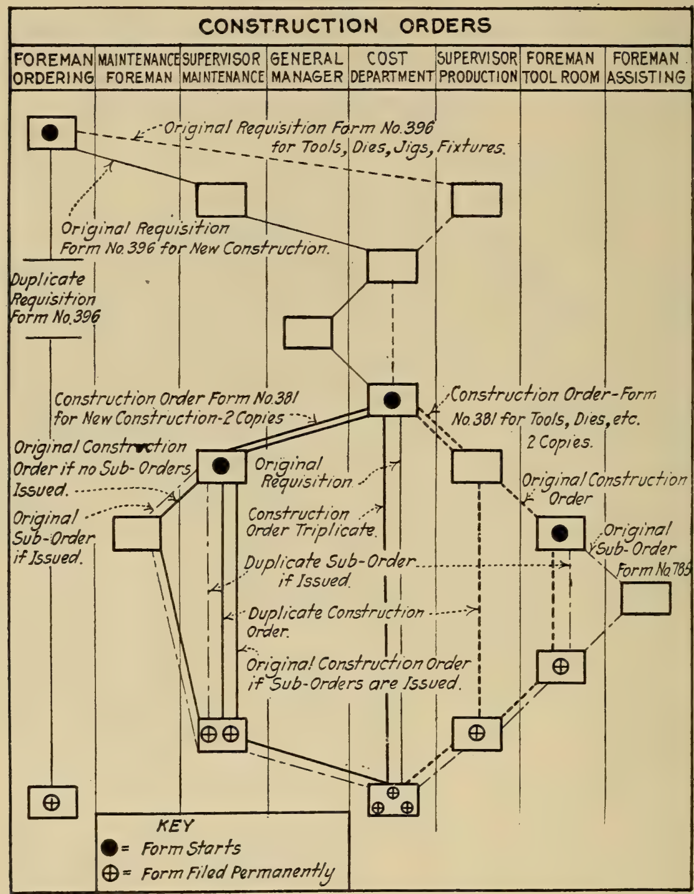


FIGURE 153. RELATION AND PROGRESS OF CONSTRUCTION ORDERS

L STAFF AND CONFERENCES. Creating an analytical and advisory body in an organization to coöperate with the executive, as well as a conference plan to make it difficult to determine where staff advice ends and line acceptance begins.

824 All through this discussion, through charts and instructions, we have been directly organizing. It is the function of this chapter to consider organization from the standpoint of the final tie-up into a coördinated whole.

825 Organization not only applies to the functions of a business and its personnel: it is just as necessary from the

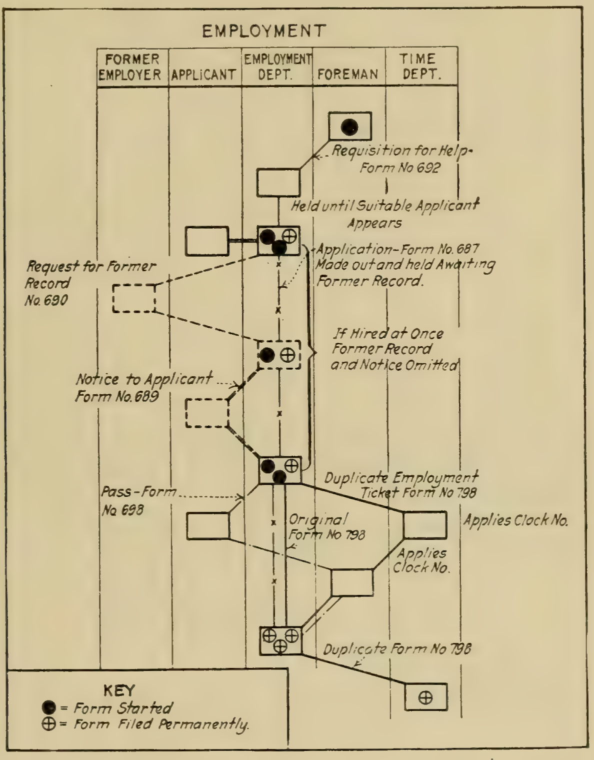


FIGURE 154. EMPLOYMENT PROCEDURE

standpoint of methods and detailed procedures. An organization is a group of functions, working through methods that must be followed, which means—

A Functions.
B Methods.
C Instructions.

826 Descriptions, whether as to A, B or C, must of course be carefully and accurately although simply written

up, and then, in so far as possible, *put in graphic form.* Many firms have in the past written up their organization details, only to discard the practice due to the inability to get the personnel to use them as their guide; or changes are

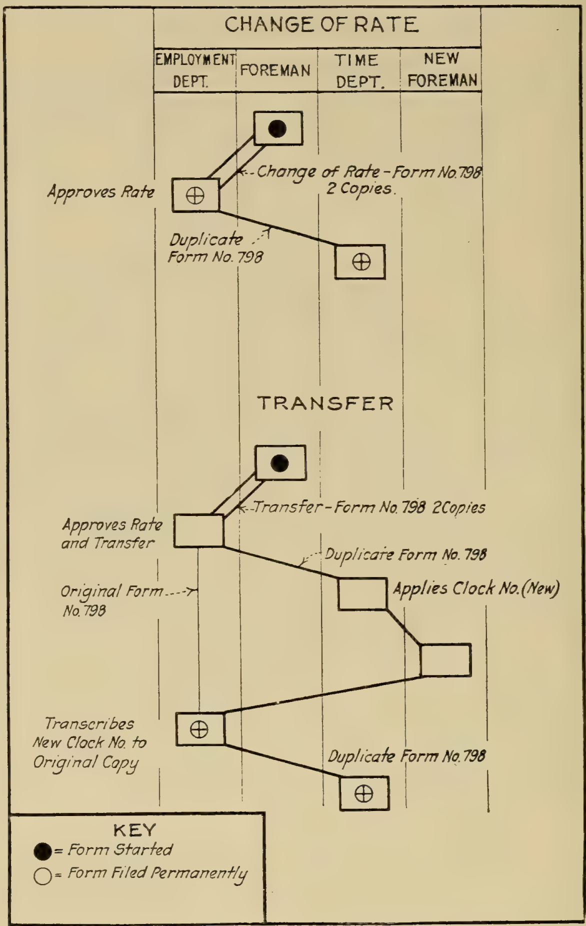


FIGURE 155. CHANGE OF RATE PROCEDURE

made without incorporating the changes in the instructions, leading to inaccuracies and therefore discrediting them, when, if the substance of the instructions had been put in graphic form *and kept corrected,* there would be no question regarding their use for reference.

827 As to Functions, these should be written up under the headings:

A Definition of function.
B Duties of the individuals responsible.

828 As to Methods, complete descriptions should be written up, explaining them in a comprehensive manner and showing all forms and records used.

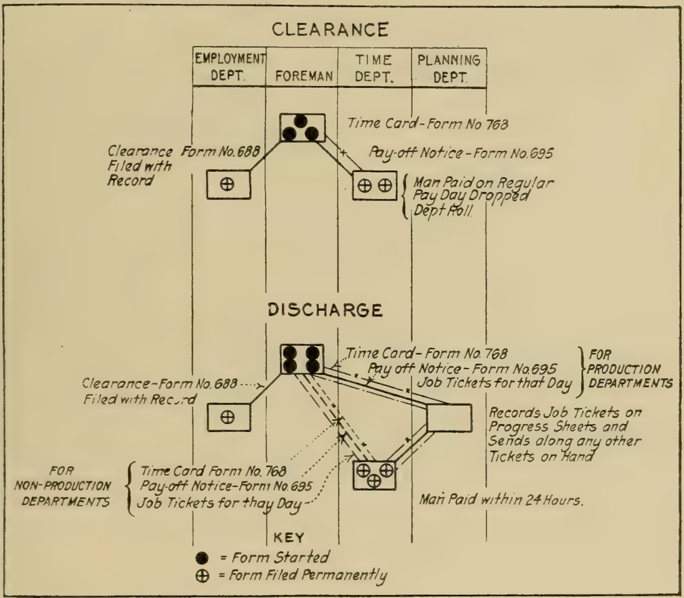


Figure 156. Clearance and Discharge Procedure

829 As to Instructions covering the carrying out of the methods, these should be written up under the head of—

Purpose of method.
Forms used.
Files used.
Method handled by.
Procedure in handling.

830 This chapter will not go into details as to the written outlines covering functions, methods and procedures, as we are more concerned with the graphical phase

of the work, recognizing also that industry is familiar with the subject of written instructions.

831 In presenting this subject of graphical presentation of organization details, the best plan to pursue is to reproduce a number of charts illustrating what is in mind.

832 Figure 142 covers the matter of organizing for industrial engineering service. Figures 143 to 146 cover line and staff organization, with further elaboration at Figures

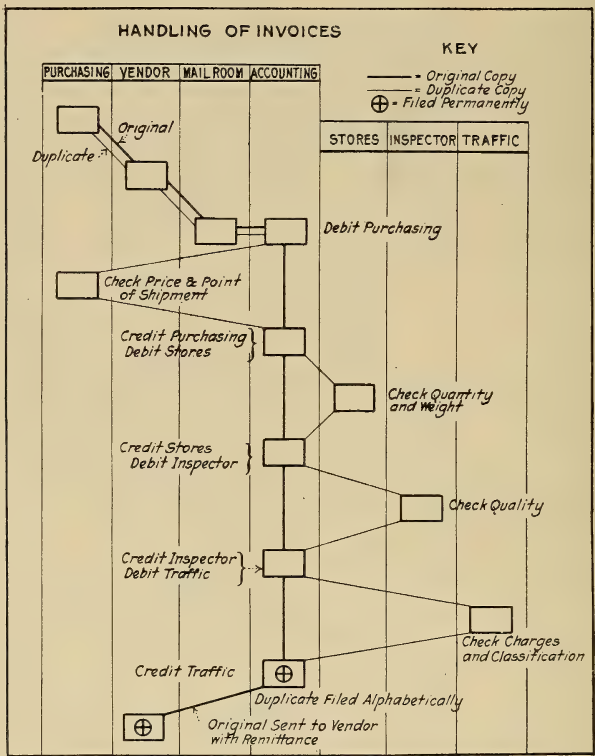


FIGURE 157. HANDLING OF INVOICES PROCEDURE

147 and 148. Figures 149 to 151 illustrate cost and accounting methods. From Figure 152 to Figure 157, detailed procedures are shown graphically. Figures 142 to 148 cover the matter of functions; Figures 149 to 151 cover methods; while the balance have to do with instructions.

833 A study of these charts will show the great value of graphically illustrating organization details, methods

and procedures from the standpoint of their better and wider use, and will also show the superiority of graphic over written presentation when the matter of quick comprehension is considered.

Chapter XXIV

GRAPHIC PRODUCTION CONTROL IN ITS RELATION TO STANDARDIZATION

834 Graphic control methods, because of their nature, force the consideration of standardization. The determination of standard hourly productions, the analysis of operations and equipment capabilities, the assignment of operations to the machines on which they can best be performed, the assignment of specific tools and auxiliary equipment such as jigs to operations, and the working up of feed and speed charts, is all standardization work. Not only is a large amount of standardization work necessary in the introduction of graphic control methods, but these methods when installed show so clearly the losses due to lack of standardization as to force its consideration.

835 Standardization is probably the most important factor in economy of manufacture. It might be defined as the determination of that which is best in materials, equipment and methods, and the fixing of these determined standards as common practice.

836 Standardization is one of the greatest uncultivated fields for improvement in American industry. The average plant has as yet no conception of the economies which can be effected by this means. All varieties and makes of equipment will be used for identical operations though only one is best for the purpose. Workmen will shape and grind their tools in accordance with their own inclinations. All will be different and yet one shape only gives the greatest operating results. Each workman guesses at the best speed for his machine and no means are provided so that he can accurately determine the best speed.

837 A clock manufacturer was found to be making hundreds of varieties of movements with non-interchangeable parts. A few varieties of movements with many interchangeable parts were found to satisfy all the needs of his customers and a great reduction in cost of manufacture and an increase in production were effected. A spectacle manufacturer in attempting to meet the individual tastes of all his customers had adopted so many different styles and sizes of frames, fastenings, ear-pieces, and bridges, all made in so many different carats of gold, that it was found that by using different combinations of these they could manufacture for years and never turn out any two frames alike.

838 One of the best illustrations of standardization and what it will accomplish is the manufacture of the Ford car. Buildings, equipment, materials, tools, operations, and methods are all absolutely standardized, and the product manufactured of standard parts. The consequence is that no other automobile manufacturer has ever been able to compete with it in price or in quality given for money expended, despite the excellent profit made on each machine sold.

839 Standardization was the greatest and most necessary problem with which this country had to deal during the war. Each war product had to be standardized so that it could be repaired with standard parts no matter which manufacturer produced it. This eliminated the necessity of carrying different repair parts for different makes, which would have enormously complicated the task of making repairs at the front. It was even found advisable to modify the rifle so that its ammunition would be interchangeable with that used by the British rifles.

840 It will be impossible to give more than a brief outline of the scope and importance of this work in the restricted space which can be allotted to it in this book. Standardization as applied to industry naturally divides into the following classifications:

Standardization of product.

Standardization of buildings.

Standardization of machines and equipment.
Standardization of tools.
Standardization of raw materials and supplies.
Standardization of operations.
Standardization of methods and policies.

841 Standardization of product is foremost in importance for it determines the entire character and scope of the business. When the product has been definitely standardized it makes possible the determination of its position in the market in respect to similar and competing articles, and the determination of the standard sales policies, methods, and arguments necessary to dispose of it in the desired quantities. The product determines the building and equipment requirements, the necessary machines and their arrangements, the standard materials and supplies required, and the operations for manufacture. It is the basic factor around which an industry is moulded, and should be considered from all angles by the best brains in all branches of the organization.

842 From the sales viewpoint the product must be standardized to take a certain definite position in the market, and be the best value possible at the price necessary to give the required profit. It must accomplish more, be more substantial, be easier to maintain, or be cheaper than other similar products. Standardization of stresses and factors of safety to meet requirements without excess material assures good value. Standardization of minor parts to commercial standards assures the quick obtaining of repair parts. Design for accessibility provides for easy repair or adjustment.

843 From the purchasing viewpoint the product must be standardized to use purchased parts or raw materials which are readily obtainable in the desired quantities, and which are the most reasonable in price consistent with the use to which they are to be put. They also require standard specifications which assure the purchasing of the exact goods required and standard tests by which the materials received can be accurately checked for conformation to specifications.

844 The production viewpoint is most exacting in regard to standardization of product specifications. Materials used must be those which allow the greatest speed in performing the various operations, or which can be most economically fabricated. They must be of a quality which will reduce spoilage to a minimum.

845 Parts should be standardized so as to require the fewest possible number of operations to complete them, and so that they may be readily set in the machines for each operation without the necessity of expensive jigs and fixtures. They should also be designed so that the various operations can be performed by standard instead of special tools.

846 Similar parts of various products should be made interchangeable so that fewer parts have to be made, purchased, or carried in stock, and so that larger quantities of parts can be put through an operation at one time. Standard limits of size should be set so that parts can be assembled without excess fitting work, and so that the broadest possible limits of accuracy are allowed in order to increase the speed of operations.

847 It is also important to standardize process inspection tests, presentation of the details of design for shop use, the names or symbols by which the various parts and assemblies are known, so that a knowledge of one set of symbols will be sufficient for the interpretation of all data or drawings.

848 The design and layout of buildings is of prime importance in effecting economy of manufacture. Unless they are designed specifically for the correct housing of the apparatus required for the construction of the particular products under consideration, and unless provision is made for expansion, serious production difficulties are bound to occur. Confusion due to neglect of this factor is found in the majority of industries which have been subject to rapid expansion. Departments will be jammed in wherever it is convenient to construct an addition, without relation to economy of production. Departments will be split into separated sections because it is impossible to enlarge the original space allotment. In one plant columns were so ar-

ranged that only one machine would go in a bay in which there was nearly space for two machines, with a consequent loss of forty per cent. of the floor space.

849 A standardized type of construction should be adopted, suited to the class of product to be manufactured, and due consideration should be given to the ability economically and quickly to procure similar materials for maintenance or additional construction. The type must provide light, strength, and ventilation in accordance with the class of manufacturing to be pursued.

850 The unit of construction should be standardized with consideration of process routings and the size of desirable increments to buildings in case of expansion. The members must be selected with reference to floor weights, crane loads or other overhead weights, and vibration.

851 The spacing of columns, size of bays, clearances and other measurements can be designed to best advantage if full consideration is given to the spacing of machines in the bays, support for hangers, uniform line shaft and belt lengths, supports for cranes, and space for trucking aisles or industrial railways arranged to give an efficient transportation system.

852 Arrangements should be considered which will allow separate space to each department necessary to production, such spaces being selected with reference to material routing in each department and from one department to the next. Wherever possible, each department should be allowed a free side or end which can be extended to take care of growth, without changing the physical relations of the departments or interfering with the routing of material. It is advisable to construct a chart showing the general layout, and the changes in layout which will be necessitated by expansion. This will assure adequate provision for all contingencies which may arise.

853 The next item in importance is the standardization of machinery and equipment. There is a "best" machine for every purpose and usually a multitude of types to select from, making the task of selection difficult. It is only by an analysis of each move in the manufacture of the product

and the speed of that operation on the various classes of machines, that the best selection can be assured.

854 That little attention is paid to the standardization of equipment is evidenced in many plants by the wide varieties of machines used for the same identical purpose. It sometimes seems as if the management had changed its mind as to the best type of machines for the purpose as many times as there were types of machines to select from.

855 Not only is it impossible that all of the varieties installed are equally good for the purpose, but the use of different machines for the same purpose introduces excessive complication in the standardization of operations. Different standard times must be set for each type of machine, different tools may be required, different instructions must be issued to the operators, who will require different training, and different helping charts will have to be devised. The productions on the various types are not comparative, and neither are the costs of that production nor the abilities of the various operators.

856 Not only must the machines directly used in production be considered in the process of standardization, but the tools and accessories used in connection with them, and all assisting equipment, such as power generating and transmitting equipment.

857 The power plant is the heart of an industry and must be so designed as to assure an even, uninterrupted flow of power to the machines. The power plant should not have any unit of such size that its breakdown would seriously cripple the production of the plant unless outside power may be called on. It is preferable to select a number of units with a total capacity in excess of that required by at least the effort of any one of the units. This allows the shut-down of any unit for repairs without inconvenience.

858 Another point to be considered in this connection is the installation of additional units to take care of expansion. Where the smaller units are used, capacity can always be increased by the addition of another standard unit similar to those installed. The adherence to one type and size of unit simplifies the maintenance problem.

859 The same process of standardization applies to the

main transmission lines. Instead of using one large drive, it would be preferable to use two smaller drives, either of which would be capable of being overloaded to the extent of carrying the entire load while the other was under repair. In electrical transmission it is advisable to have two means of getting power to any department, and arrangements should be made so that changes can be made to allow the transmission of additional power to provide for expansion without excessive expense.

860 Motors, shafting, hangers, clutches, belts and other power transmission devices may be so standardized as to simplify greatly maintenance and upkeep problems. Where the same makes and types with a limited and carefully selected gradation of sizes are used, the repair parts to be carried will be reduced to a minimum, and the repair men will become specialists on the limited types selected and be able to make quicker repairs at less cost.

861 Standardization of the inspection and care of transmission machinery is of great importance. Standardized routes for oiling, cleaning, adjustment and inspection will prevent breakdowns and reduce maintenance costs. The same type of inspection of all machines is advantageous and not only assures more continuous operation, but keeps them maintained in a condition which assures more accurate work and better production. There is much production lost because operators run equipment which is in bad repair until it breaks down, rather than to have it shut down at the first indications of trouble.

862 The standardization of production machines not only makes it necessary to carry a greatly decreased variety of repair parts, but also permits the repair men to become specialists in their repair and adjustment. It also simplifies the training of new employees and allows the transference of operators from one machine to another without loss in their speed of production.

863 The standardization of small tools usually offers great opportunities for improvements resulting in increased production, especially because this subject receives so little consideration in the average plant. As with the large machines, there is one definite standard tool for use in

the machine which will give the maximum production for each specific operation. The tool must be of standard material, shape, size, and also, if it is a cutting tool, must be ground to standard specifications and not in accordance with the individual whim of the operator. The average operator who sharpens his own tools is inclined to use them until they are too dull for efficient work before he will leave his machine to grind them.

864 The standardizing of small tool equipment requires the working up of standard specifications of the tools and supplies, which will give the maximum production for each and every operation performed, and of those tools and supplies required for each class of employee. There must also be a standard quantity of each class of tool on hand which will be sufficient to supply all operations with a reserve for replacements.

865 When standard tools have been made available, standard means must be devised to assure the delivery of the proper tools to the workmen for each operation performed. It is as important to get the right tools to a machine as it is to get the right materials, and provision for the control of the supply of tools must be incorporated in the general control system.

866 Jigs and fixtures can be considered as having the same importance in relation to the efficiency of the operation performed, as tools and materials. They must also be brought under the control system, and should be standardized as to design for the operation to be performed, and as to quantity necessary to supply all similar operations liable to be under way at the same time.

867 The proper control of tools requires the standardization of methods of stocking, the same bins, racks, tool checks, methods for accounting for and issuing tools, methods and facilities for inspecting tools, and methods for repairing and adjusting tools. The location of tool stocks and cribs must be standardized to facilitate disbursement.

868 In order that standard tools shall produce at the standard rate of production, it is necessary that they shall be adjusted and used in a standard way and run at standard speeds. This requires the working up of standard in-

structions to the workmen. These instructions are best embodied in helping charts, preferably in graphic form, which are placed at the machine. These not only assist the workman in the use of tools, but permit the checking of speeds and the use of tools by the foremen.

869 We have now covered those features of standardization which apply to the building and equipping of the plant, and the determination of the product to be manufactured, and are prepared to proceed with those problems which relate to the actual manufacture of the goods in question, such as the materials to be used, the operations to be performed, and the methods and policies of the business.

870 As there is a best machine and a best tool for each operation, so is there a best material for each part to be manufactured. The standard material to be used may be defined as one which can be readily fabricated at low operating cost, which is reasonable in price, and which has physical and chemical characteristics suitable for the use to which it is to be put.

871 The operating cost of handling materials is an important factor to be considered in standardization. A large saving was made for a silk-ribbon mill by using a better and more expensive grade of silk. The saving made by eliminating a large percentage of the delays to looms due to thread breakage paid the additional cost of the silk and left a very satisfactory profit.

872 The first problem in the standardization of materials is, then, the determination of those qualities which permit low cost of manufacture. These qualities must be carefully balanced against price, as there is a point where the reduction in operating cost is just balanced by the increase in price.

873 Those characteristics of the materials which give strength, such as chemical composition and stress and strain features, must be standardized so as to give the correct strength to the finished part. Errors are more frequently made through excess strength at excess cost than through lack of strength.

874 Materials must also be standardized in regard to those features which produce finish and pleasing appear-

ance in accordance with the standards of quality determined for the finished product.

875 The standardization of sizes offers great opportunities for savings in wasted materials and in the elimination of useless operations for the removal of excess material. Where small parts such as machine screws are required, a saving can be made by limiting the varieties of sizes, which requires the carrying of fewer varieties in stock and allows more economical purchasing in larger lots.

876 Standard facilities must be devised for storing materials, so that they may be economically handled through transportation facilities to stores and from stores to the operation for which they are required.

877 Standard methods should be devised for the disposition of waste, the utilization of waste in by-products, and the reclaiming of scrap materials.

878 The standardization of the operations and methods of performing operations offers one of the broadest fields for investigation, correction, and the production of economies. It is a task which can well be assigned as the regular duty of one or more members of the production organization. However, it is unusual to find plants in which men are regularly assigned to this work.

879 The various executives and foremen engaged in routine production duties have not the time to devote to the intensive study required for such standardization. Moreover, the ordinary management considers this to be part of their duties, and as a consequence it is neglected and offers an excellent opportunity for outside engineers, who may be retained, to show excellent savings.

880 The following is a brief outline of the various factors to be considered in undertaking standardization work as it applies to the performance of operations:

881 Standardization of the quantities of materials to be carried ahead of each operation to assure a constant supply and prevent interruptions to the operation due to lack of material. Consideration must also be given to keeping this supply of material at the minimum amount necessary for this purpose, to reduce the quantity and value of the mate-

rial in process and the length of time that the material requires from the initial operation to completion.

882 Standard stations or locations for materials convenient to the machines, standard containers or methods of piling same, and standard means of transportation to produce economies in routing and assure a constant supply.

883 Standard methods of arranging materials at the machine to facilitate the rapid replacement of a finished piece with next piece to be worked on.

884 Standard charts for the instruction of the workman as to the speeds at which the machine should be run, and the speeds and adjustments to be used in handling the various materials and operations performed on the machine. In the machine shop these charts show for each grade of material the feed and speed to be used for any desired depth of cut, and for each machine the various speeds and adjustments of feeds which can be obtained.

885 These charts not only assure correct workmanship, and the performing of the particular operation on the particular material at the maximum speed, but also save time, as they furnish the quickest means by which the workman can obtain his instructions.

886 Standard instructions as to the tools, jigs and fixtures to be used for each operation on each class of material. This assures the use of the correct tools, saves the time usually consumed in trying to remember what was previously used, and is of assistance in getting operations started promptly.

887 Standard rates of production, including cleaning up or setting up time, for use as a basis for scheduling, to give the workman a knowledge of the speed at which he should be capable of producing, and to furnish the foremen with a means of checking up the volume of work produced by each man, and of comparing the ability of the various employees.

888 Standard sequences of operations for each part or product, based on the most economical sequence from a production standpoint, and the shortest transportation routing. These predetermined sequences also are the basis of instructions to truckers.

889 Standardized allowances of time for parts or prod-

ucts to pass through all operations to completion are of great importance both as a basis from which delivery promises to customers can be made, and to assure the allowance of ample time for completion so that the disruption and loss of production due to the necessity for rushing orders through may be avoided.

890 Standardization of the policies and methods of management and standardization of clerical and control methods in the shop and office may be considered of equal if not greater importance than the standardization of operations and equipment. The clerical methods and routine are the means by which definite courses of action are fixed throughout the organization. They determine the relations between departments, produce or destroy coöperation, and are the means by which the collection of units of which the plant is comprised are bound together and coordinated to the purpose of the industry.

891 There are few plants in which any one but the general manager would have the authority to alter or standardize systems which affect all departments. As the general manager has not the time to devote to the detailed studies necessary to perfect such systems, and as no one else has the authority, improvements in systems are usually badly neglected. Industry should develop a standardized function, in charge of an extremely competent analyst, for the improvement of systems.

892 The following is a brief outline of the various factors to be considered in the standardization of policies, methods and systems:

893 Standardization of the market policy of the company. The definite determination of just what types of products will be made, whether the business will be a jobbing business, or whether it will specialize on certain definite products. Few managers have predetermined just what they are shooting at, and many businesses are an unhappy combination of specialties and jobbing work.

894 Standardization of the policies in regard to organization. The definite fixing of the authority and responsibilities of the various executives, their relations to the com-

pany and to each other. Much disrupting friction can be avoided by the definite outlining of such policies.

895 Standardization of the functions and duties of all executives, foremen, assistants and clerks. Each man should have a definite and prescribed position in the organization, and adequate instructions outlining his exact duties. Great care is taken in instructing workmen who are to manufacture product, but executives whose efforts may mean the loss or gain of thousands of dollars are often dumped into an organization to make their own positions without any attempt at adequate instruction.

896 Standardization of sales and publicity policies and methods. The accumulation of data concerning market conditions and competition. The formulation of methods of selling, following up customers and leads, and maintaining records of sales and publicity conditions and accomplishments. Predetermining sales as a basis for predetermining production requirements. Interpreting and following up customers' orders.

897 Standardization of inspection to insure the maintenance of product quality.

898 Standardization of purchasing and purchasing follow-up methods to assure the purchase of materials and supplies at reasonable prices, and their delivery to the plant on the date on which they will be required in stock or process.

899 Standardization of the quantities of stock and goods in process to be carried, the methods of receiving, storing and issuing the same, and the methods of accounting for such materials and charging them to orders and departments, including methods of symbolizing the various accounts to which supplies are to be charged.

900 Standardization of the methods of planning, scheduling and following up work in the plant, including standardization of graphic control features.

901 Standardization of methods covering shipping, billing, collections, determinations of credit, and claims.

902 Standardization of cost-keeping to give product cost as a basis for the determination of prices and estimates, and as a basis for comparative figures on production costs,

and to give costs by divisions of the business as a basis for executive judgment of accomplishment. This includes the disbursement of and accounting for the payroll and other expenditures, and the collection of labor, material and overhead costs.

903 Standardization of financial reports and statements which reflect the true conditions of the business, and the compilation of tax returns.

904 Standardization of the compilation of data on accomplishment which are sufficiently comprehensive to form the basis for executive action to improve conditions and for executive judgment of the ability of the various members of the organization. This last function of standardization is of sufficient importance to warrant further consideration.

905 An excellent plan for the judgment of accomplishment is the adoption of the budget system. Predetermined standards of expenditure, or expenditure in relation to accomplishment, are set up and actual expenditures are compared with these standards.

906 Standard costs for the various products or parts of products may be determined and the actual costs of products compared with them to determine the economy of production, and locate those factors of production which are excessive in cost.

907 Standard schedules of production or accomplishment may be set for departments and the plant as a whole, taking into consideration actual capacities with allowances for normal production loss, for repairs, absence of labor and other factors, and compared with the actual production or accomplishment obtained.

908 The production of any department may be converted into the standard hours which should have been consumed by dividing each item by the standard hourly rate of production and totaling. This figure, as compared with the actual labor hours worked, will show the efficiency of the production of the department.

909 Standards may be set covering allowable waste, idle machine time, machine delays, labor turnover, machine-hour cost, and many other factors, and compared with actual accomplishment figures for the purpose of deter-

mining where there has been laxity and where improvements can be made through study and correction.

910 Standards may be set covering the number of each of the various classes of employees required for certain productions and the relations in numbers between the various classes. A comparison of these with actual figures will show any ineffective use of labor.

911 The amounts of materials to be carried in the various stocks and in process between operations and departments may be standardized, and the standards compared at periodic intervals with actual existing conditions. Standards may be set covering all departmental expenses not chargeable to product, such as supplies, repairs, light, heat, and power, for comparison with actual expenses to disclose carelessness and waste.

Chapter XXV

GRAPHIC PRODUCTION CONTROL IN ITS RELATION TO COSTS

912 One of the greatest problems before American Industry to-day is that of determining accurate cost of production. Industry has become so complex, our tax laws are so intricate, and the securing of accurate returns so important, that the concern operating without a knowledge of costs is in the worst possible position to conduct its business to best advantage. Another, and perhaps the most important, reason why costs must be carefully ascertained is that to enable the manufacturer to determine just what he can do in the way of increasing wages or of arranging for profit-sharing plans, or, if necessary, to offset unreasonable demands on the parts of workers, he must know exactly where he stands with reference to his production costs.

913 Competition, and the necessity for accurate returns in connection with tax laws and giving labor its proper returns, are forcing manufacturers as never before to give this important phase of industry more than the ordinary amount of attention.

914 Some years ago a trade paper contained this choice bit of logic:

> "The surgeon, for instance, certainly ought to be satisfied with his job. When he wants an extra five hundred, all he needs to do is to single out one of his well-nourished patrons, prod him viciously just below the first floating rib until he grunts, and then utter these three magic (likewise remunerative) words: 'Appendicitis; operation imperative.' This is effective salesmanship. Could any manufacturer land a contract with such dispatch? Hardly.

"Which is quite different from the manufacturing business. If a manufacturer wants to squeeze out an extra twenty-five dollars he will have to spend a couple of weeks with his cost cards and figures, and sweat and snort and chew his nails 'way up to the knuckle; and finally, when he does locate a twenty-five that he may possibly grab if he slips up to it quietly and it does not happen to see him first, along comes an unexpected bill for something or other and gobbles it up."

915 If we eliminate such considerations as lack of capital, unwise credits, extravagance and fraud, there are three factors which, whether considered separately or in combination, can cause distress to an industrial concern:

1 Lack of systematic production methods.

2 Failure to ascertain correct costs.

3 Lack of uniformity in costing or in bidding on work.

916 I believe I am safe in saying that there are two fundamentals in business which stand out so prominently as to admit of no argument:

1 Every manufacturer who furnishes a product of good quality, and who can make reasonable deliveries, is entitled to his share of the available business at a fair and reasonable margin of profit, up to the capacity of his plant.

2 Any concern which purchases a product below the cost of production is enjoying something to which it is not entitled, and which really belongs to the manufacturer of the particular product.

917 What do we mean by Costing? Is it just the gathering together of a lot of dry figures which are rarely used in a constructive fashion because of the difficulty in mentally visualizing a mass of unrelated statistics? Is cost finding to be mere history or prophecy? Is it to be used to determine what has been done in the past, without much reference to the future? Is cost compiling to be done with reference to the financial side of the business only, or is it

to be of pronounced assistance to the other branches of manufacturing?

918 It is in this connection that Graphic Production Control bears a direct relation to Costing. Through our Material Control we are sure of accurate records as to purchasing, receiving, storage, issuance and transportation of material; through Product Control we know what enters into the manufacturing, the quantities to make, and when; through Equipment Control we are kept posted as to idle equipment and the causes, repairs, use of equipment and the like; through Labor Control we have accurate information as to the time spent on work, idle time, pieces good and bad, piece rates and bonus payments, overtime and night work.

919 Graphic Production Control must consider all these in order to control production intelligently. It must know what work is done, of whatever nature (Product); where it is done (Equipment); by whom it is done (Labor), and with what it is done (Material). As will be appreciated, a knowledge of these elements is just as necessary to the collecting and compiling of costs as in controlling production. Naturally we are in business to produce goods, *hence our first aim in production is PRODUCTION.* Having provided our mechanisms for securing production, we use the same machinery, provide proper coördination factors, and we have our costs of production. This is what has justified the author's statement that costs are an indirect result of Graphic Production Control.

920 In controlling all material we take into account both direct material (production) and indirect material (expense). In controlling all labor, we are informed as to both direct and indirect hours of work done. We know our spoilage and the idle time of both worker and equipment, which are overhead or burden elements. We know what has been produced for both production and expense purposes, as no proper installation of production control would be at all complete without system of orders covering products to be made for trade and plant use, construction, maintenance and the like. Certainly we have all the basic elements entering into cost-keeping, and all that remains is to

provide the coördinating mechanism which will give us Cost Control. This mechanism consists of—

A A code of standing order numbers by departments to which all elements, whether labor or material, not having to do with the manufacture of goods for sale can be charged.

B A knowledge of expenses not directly chargeable to plant operations, properly classified (1) by departments and (2) according to the business as a whole to be apportioned to the product manufactured.

C Proper books and records for both costs and general accounting, which can act as the clearing house for all expenditures, of whatever nature.

921 With these provided, we can take the same information supplied through the medium of Graphic Production Control and compile costs of production, prepare burden statements and develop monthly trading statements showing profits and losses.

922 Certain fundamentals must not be overlooked, as follows:

A In the chapter on Equipment Control we outlined the economic importance of standardizing the departmental overhead rates, carrying the differences between standard and actual overhead costs into an adjustment or profit and loss account. This, with the plan of considering idle time of men and machines as overhead, will put the plant on a normal basis (even if assumed), and will eliminate the factor of idleness in labor and equipment from the regular cost calculations.

B Costs accounting and overhead compilations should be on a monthly basis, making possible the analysis of results twelve times a year.

C The money value of material must be considered in the material inventory plans, so that the financial side of the material end of the business will coördinate with the other financial considerations, material being simply another form of money.

D It is just as important to know what things should

cost as to determine what they do cost; hence provide for predetermination of costs.

E Proper monthly overhead statements by departments and accounts, making possible intelligent comparison of burden expenditures.

F Costs by operations or orders by product, so as to have a means of comparing actual costs with predetermined costs.

923 Indirectly, Graphic Production Control leads to Cost Control. Determining standard productions, as expressed in units per hour, in a sense determines the cost of the work,—from the standpoint of *time,* at any rate, which, after all, is our real productive investment. We know the costs of labor and material, and can arrive at average costs for each. We know our standard overhead rates, and from actual times and quantities of labor and material reported can arrive at our actual cost sufficiently close for all practical purposes. Consider this also: *So long as a job or operation is up to or ahead of the schedule as expressed by standard hourly productions, costs are bound to be within the prescribed limits.* Hence what should be watched *are the costs of work which fall behind schedule, as here is where the losses occur.* Thus you have within your control and in the hands of your shop personnel, giving them a direct point of contact in connection with the *cost reduction,* through the medium of your production-control machinery, the data necessary to watch costs *during process of work and not after completion.* In other words, determine equivalents and watch actual results which do not measure up, for those which do are taking care of themselves. Do not overlook the enormous importance of the influence on shop officials of putting them in such direct touch with this matter of costs through having standards and "flagging" actuals in excess of them.

924 The above does not mean that actual costs of production are not to be compiled in an accurate or scientific manner. Actual costs are very necessary in order to operate a business properly, to keep the financial records, and to compare actual costs with your predeterminations.

925 What I am urging, however, is that the Graphic Production Control mechanism be used to the utmost extent possible in anticipating increases in costs, standardizing and predetermining costs, and in this way producing much more economically than would otherwise be the case. In other words, compile actual costs, but arrange for predeterminations. Go at the costing from an engineering viewpoint.

926 If the above points are observed along with the other points discussed heretofore, your Graphic Production Control installation will go a long way toward measuring up to the ''aims and purposes'' outlined in the eleventh chapter.

927 It is not the purpose of this chapter to go into the matter of details as regards how to collect and compile costs of production, as this would require much more than a single chapter could cover. Enough has been discussed, however, in this and other chapters to pave the way to efficient costing. Essentials and laws have been defined, specifications outlined and methods described, which are just as necessary in costing as in controlling production. What should be done is to take these same tools and use them in keeping costs.

928 It can, therefore, be seen what a direct relationship exists between Graphic Production Control and Costing. Through the one we have all the elements necessary for predetermined costs based on the engineering viewpoint. Through the other actual costs can be compiled, using the machinery of production control and the coördinating mechanism previously outlined. Having both, comparisons will lead to improvements, to further refinements and, finally, to *cost reduction.*

Chapter XXVI

GRAPHIC PRODUCTION CONTROL AND THE LABOR PROBLEM

929 One of the greatest problems occupying the attention of production managers is that generally known as "the labor problem"; and as there is a direct relationship between this problem and Graphic Production Control, it was felt that it should be considered in this discussion.

930 In one sense the basis of industry is labor, and since labor is getting to be more and more a factor in industrial management, it is going to be influenced by, or will influence, this great question of production control We cannot get away from this conclusion, so why dodge the issue, leaving the problem to take care of itself?

931 No discussion from an economic standpoint will be indulged in here, as this will be treated in the final chapter, on the Economic Aspects of Graphic Production Control. What we will seek to do is to discuss this problem with reference to the matter of controlling production, regardless of what labor should do or not do in eliminating inefficiency or helping to bring down the high cost of living.

932 In controlling production, we aim to coördinate work, machinery, material and human effort, and upon the interest and coöperation of the human element rests much more than may be imagined. In approaching this problem, six important and, to the writer, fundamental considerations should therefore be set forth:

A Men can accomplish more than they usually do.

B As a business is usually conducted, neither management nor men know what constitutes the best a man can do.

C Each man should see an ideal ahead of him that his mentality can comprehend, for just as surely as he attains it one still higher replaces it.

D In all the world there are no two persons exactly alike, and efforts should be made to reconcile the differences.

E Effort, interest and exertion are just as important as attaining an ideal, and should therefore be considered.

F Inefficiency and responsibility of management should be separated from those of man.

933 In connection with the above points, the matter of equivalency is considered the keystone. We have a right to expect a certain return for a certain expenditure, and this should be a fair return *which will not prove detrimental to health and well-being of worker, or to condition of the equipment.* This return should be determined by competent parties, who know what they are talking about, and who can inspire confidence in those affected. Returns in the form of standards should not be the *best* performance of the *best* worker, which would mean a killing pace for the average and mediocre workers, but should more closely approximate an *average* attainment of an *average* worker, thereby placing the standards within the reach of the mediocre men, and enabling the best men to beat the standards set. A mean between the average and best attainments of the workers of average ability would seem to be the best standard.

934 We should have a means of measuring attainments and watching progress toward or away from a possible attainment. Any failures to attain equivalents determined upon should be shown, so as to distinguish between that inefficiency *for which the worker is responsible,* and the one *within the control of the management.*

935 Standard hourly productions are really the measuring-sticks in industry, and constitute the basis for enabling us to give due consideration to the six points above mentioned. Without them, we are in a blind alley, in addition to which we are without adequate means of controlling production, *through not knowing the length of time any given*

piece of work will take between definite points, making it difficult to dispatch work. Nor have we a real basis for wage increases to those who deserve them, and we certainly cannot consider piece-work or bonus plans unless we know equivalents. So from every angle we should know standard hourly production, whether the plan of payment is piece-work, bonus or day-work; in fact, it is more important on the day-work basis than on the others mentioned, for the reasons above given.

936 Labor cannot object to rates that are fairly set, and certainly no rates should be unfairly set, nor is the average management desirous of having unfair rates, as they operate in the long run to the detriment of the business, through strikes, opposition of workers, restricted production and the like.

937 As has been pointed out previously, the real productive factor in industry is *time,* and as time is conserved, efficiency is increased, which makes for cost reduction, and therefore greater industrial success, and gain to worker, employer and consumer alike. To conserve time, it must be watched, controlled, compared with standards and the ratio of efficiency established. This ratio should be known as to men, plant and management.

938 These standard hourly productions can be determined through a time-study campaign, or, as we have advocated, through estimates at the start, with refinements made as the work progresses. These estimates can be made by observing work, talking with foremen and workmen, studying past performances and setting up temporary schedules of pieces per hour, which can later be made permanent.

939 Our control boards, in a measure, indicate efficiency of operations, but they do not give a true index of the efficiency of a man or management, for the reason that what we are scheduling is work to be done by men and machinery, the latter two being incidental to the first. It is *work* we want to watch the progress of, in controlling production; it is work we must coördinate throughout the various operations, and the flow ahead of, or behind, a prescribed schedule must be considered constantly. The failure to supply

material, or the idleness of equipment, may throw the work behind schedule, *but we cannot give the work credit and still observe graphically its true progress,* even though we would do so were we considering the efficiency of men and departments. What we do is to place signals on the boards, to indicate reasons for failure to attain schedule. We do provide for watching and increasing the efficiency of work by noting the exceptions and getting after limitations, and in this way speeding up production.

940 There is a different aspect to consider, however, when we come to man and department efficiency. It is not the fault of the man if there is no work. It is not the fault of the man if failure to anticipate a breakdown occasions several hours' delay. Without material the man must loaf, but is he to blame? Hence those things not within his control must be credited to him and *charged to the management;* then we are giving all sides a fair deal, and are in a position to determine where responsibility for inefficiency really rests.

941 The great question is, how can we do this? *By using the same mechanism in operating our control boards, and transferring the information it supplies to efficiency records covering men, management and plant.*

942 As to the man, there are three factors to consider:

A The time he spends in the plant.

B The work he is credited with in pieces, in terms of standard hours.

C The time he spends in *not* producing, for reasons *not* within his control.

943 In determining his efficiency the calculation is:

$$\frac{\mathrm{B}}{\mathrm{A-C}} = \% \text{ of efficiency.}$$

944 In determining the efficiency of the management the calculation is:

$$\frac{\mathrm{A-C}}{\mathrm{A}} = \% \text{ of efficiency.}$$

945 In determining the efficiency of the plant, the calculation is:

$$\frac{\mathrm{B}}{\mathrm{A}}$$

which is the *product* of the efficiencies determined at 943 and 944.

946 In Figure 158 is illustrated an unusually vivid graphic history of an employee's efficiency. Weeks are shown down the side, 13 to the record, or a quarterly period. Across the top are the standard working hours of the

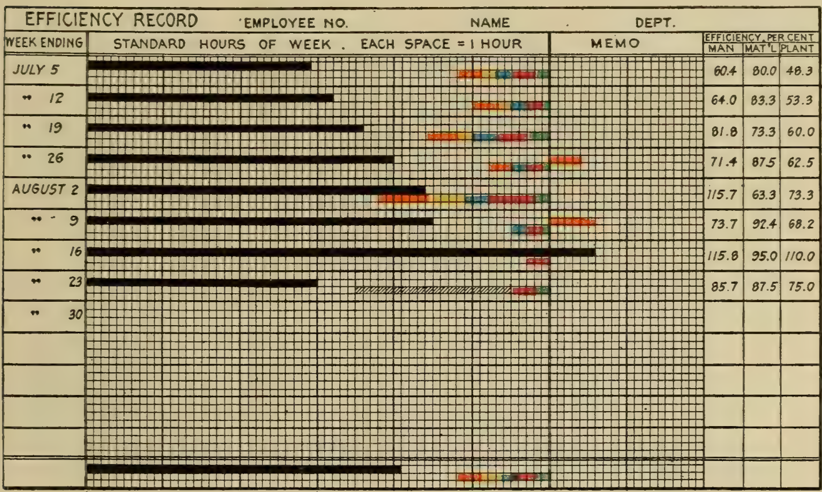


FIGURE 158. PERSONNEL EFFICIENCY RECORD

week, without reference to the days of the week. Provision is made for "memo" entries and also for showing the efficiency of man and management and plant. From the left-hand edge we credit the worker daily for production in black, and from the right-hand edge for delays he cannot control, the totals being posted at the end of the week in colors. Delays are posted under the regular graphic scale, for reasons which will be apparent later.

947 It will be noted that for week ending July 5, the worker was credited with 29 hours in standard hours of production. As he worked on this production 48 hours (60 hours in the plant less 12 hours in delays), his efficiency is $29 \div 48$, or 60.4%. From the standpoint of management efficiency, the man could work only 48 hours, although he was on hand ready to work for 60 hours, hence the efficiency

is 48 ÷ 60, or 80%. The plant efficiency is 48.3% (29 ÷ 60) as found by multiplying 60.4% × 80%. For week ending July 26, we find that the man worked 4 hours overtime, shown by orange at the right of the vertical line for end of standard week. This total would naturally be added to regular totals in calculating efficiencies. For week ending August 2, we notice that the man spent 38 hours on production, for which he receives a credit of 44 hours, so his efficiency is 44 ÷ 38, or 115.7%. For week ending August 16, he betters his schedule for the week by 6 hours, as indicated, and his efficiency is 66 ÷ 57, or 115.8%. These last two illustrations show the reason for entries on the two horizontal scales, as we do not want them to conflict. For week ending August 23 we observe that worker was absent for two days, as shown by diagonal black lines.

948 The average for the 13 weeks is shown at the bottom, 85.4% being the worker's efficiency, 80% the efficiency of the management, and 68.3% as the efficiency of the plant.

949 Regarding the color scheme at the right of the record, this gives the various causes of the delays. See Figure 13, Chapter XI, for standard key to colors. For week ending July 5 there were delays of:

2 hours—no material.
3 hours—defective work.
2 hours—no work.
2 hours—no tools.
3 hours—machine down.

—and at the bottom we have an average as to each cause covering the weekly average of 12 hours for the 13 weeks.

950 A word is necessary regarding the credit for defectives. Rejections are of two kinds:

A Spoiled work for which the worker is to blame.

B Defective and spoiled work for which he is not to blame.

Hence we credit him for the latter.

951 In other words, we compare the actual hours spent on production (a charge to the worker), regardless of the hours spent in the plant, with the credit of standard hours

of the work produced, to get the efficiency of the man. We compare the hours the man spent in the plant, which he could have worked, with the actual hours he spends on production (total hours in plant, less delays for which he is not to blame), and we have the efficiency of the management. We compare the hours he spends on work with the hours spent in the plant, and we have the plant efficiency.

952 Note the ease with which improvement in efficiency of both man and management can be observed. In one case it is indicated by an increase of black toward the right; in the other, by a decrease in the colors. The best weeks and the worst weeks for both man and management can easily be observed, as, for instance:

Class	Best	Worst
Man	August 16	July 5
Management	August 16	August 2
Plant	August 16	July 5

953 Note, also, the ease with which causes of delays can be followed by reading the distinguishing colors *down* the sheet.

954 As will be seen, the record is quite comprehensive, showing:

Overtime.
Absence.
Time spent in plant.
Actual hours on production.
Standard hours' credit.
Delays.
Elements in delays.
Efficiency of man.
Efficiency of management.
Efficiency of plant.

—its graphic feature being of special importance.

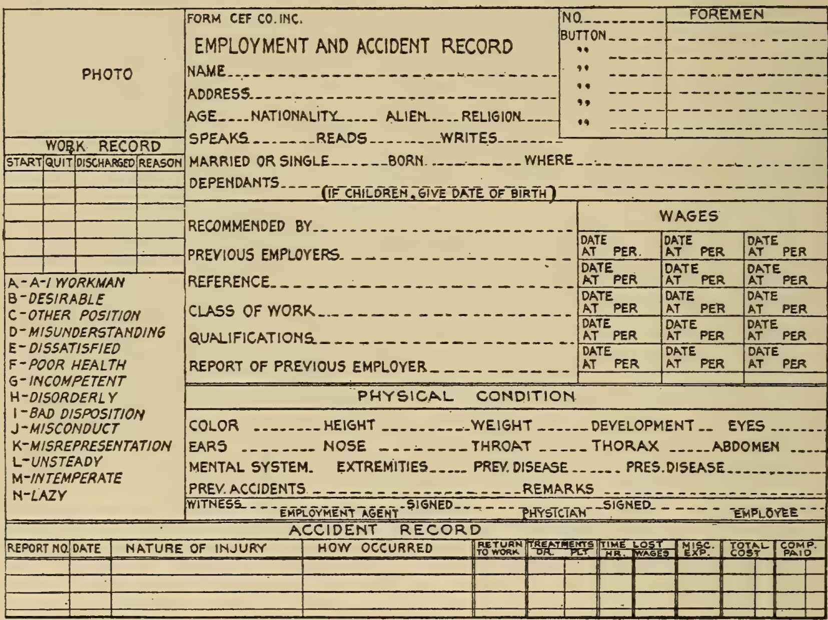
955 From it such questions as the following can be answered:

Is the worker making the improvement he should?
Are his gains consistent or spasmodic?
Is he receiving the wage increases he should have?

Is he regular in his attendance?

How long did it take him to attain an average efficiency of 85%?

956 So much for the efficiency of the man. By assembling the same information on a weekly sheet, according to departments, with workers' names down the sides, we can



PHOTO

FORM CEF CO. INC.

EMPLOYMENT AND ACCIDENT RECORD

NAME

ADDRESS

AGE NATIONALITY ALIEN RELIGION

SPEAKS READS WRITES

NO. | FOREMEN

BUTTON

WORK RECORD

START	QUIT	DISCHARGED	REASON

MARRIED OR SINGLE BORN WHERE

DEPENDANTS (IF CHILDREN, GIVE DATE OF BIRTH)

RECOMMENDED BY

PREVIOUS EMPLOYERS

REFERENCE

CLASS OF WORK

QUALIFICATIONS

REPORT OF PREVIOUS EMPLOYER

WAGES

DATE AT PER	DATE AT PER	DATE AT PER
DATE AT PER	DATE AT PER	DATE AT PER
DATE AT PER	DATE AT PER	DATE AT PER
DATE AT PER	DATE AT PER	DATE AT PER
DATE AT PER	DATE AT PER	DATE AT PER

A-A-1 WORKMAN
B-DESIRABLE
C-OTHER POSITION
D-MISUNDERSTANDING
E-DISSATISFIED
F-POOR HEALTH
G-INCOMPETENT
H-DISORDERLY
I-BAD DISPOSITION
J-MISCONDUCT
K-MISREPRESENTATION
L-UNSTEADY
M-INTEMPERATE
N-LAZY

PHYSICAL CONDITION

COLOR HEIGHT WEIGHT DEVELOPMENT EYES

EARS NOSE THROAT THORAX ABDOMEN

MENTAL SYSTEM. EXTREMITIES PREV. DISEASE PRES. DISEASE

PREV. ACCIDENTS REMARKS

WITNESS EMPLOYMENT AGENT SIGNED PHYSICIAN SIGNED EMPLOYEE

ACCIDENT RECORD

REPORT NO.	DATE	NATURE OF INJURY	HOW OCCURRED	RETURN TO WORK	TREATMENTS DR.	TREATMENTS PLT.	TIME LOST HR.	TIME LOST WAGES	MISC. EXP.	TOTAL COST	COMP. PAID

FIGURE 159. PERSONNEL EMPLOYMENT RECORD

show the efficiency of all workers in the department, and the efficiency of the management and plant for this department. By making a composite of all department records, we have a plant record showing efficiency of men, management and plant.

957 By working on the exception principle, we can determine at a glance the department showing the greatest man inefficiency, and that showing the greatest management inefficiency. By referring to the various department charts, the most inefficient man in each can be quickly determined, as well as the most inefficient management factor. Knowledge of limitations is but a step to improvement, and

it is here that these man and management graphic charts can be used to decided advantage.

958 Our control boards give us the efficiency of work, idle-time reports give us the efficiency of equipment, rejection reports give us the efficiency of materials, and this record, Figure 158, gives us the efficiency of men and departments and, equally important, the efficiency of the management and plant, which are generally ignored in efficiency calculations.

959 All the responsibility for inefficiency does not by any means rest upon the workers, nor is all the blame to be attached to the management. If workers are slow or incapable or unwilling to make schedules within their reach,

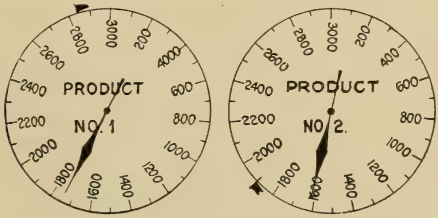


FIGURE 160. GRAPHIC DIAL

they will be found inefficient. If the management is careless or negligent, and unwilling to exercise proper foresight, it will be found inefficient. The product of man and management efficiency gives plant efficiency. What I urge is a means whereby this inefficiency can be uncovered and *all sides treated fairly at the same time.* Study of the graphic presentation here shown will indicate how well this matter of man, management and plant efficiency has been covered. It is sincerely believed by the author that Graphic Production Control, as generally outlined in the other chapters in this book, and more specifically treated in this chapter, has an appeal in it for labor, and will be a factor in the proper solution of the great labor problem confronting us.

960 In connection with the above we can arrange to give due consideration to the employment and accident details concerning each worker. By using Figure 159 as the re-

verse of the personnel efficiency record, we can assemble in one record all the pertinent data regarding each worker. On this reverse side we can show the entire history of the worker as regards his engagement, wage increases, work record, and accident record. The figure will be found self-explanatory.

961 As an aid in showing efficiency of work done graphically, Figure 160 is offered, being a graphic dial which shows throughout the day what has been accomplished, covering the product manufactured, or the showing of a department, or, if desired, the workers' showing.

Section V

CONCLUSION

Chapter XXVII

PITFALLS OF GRAPHIC PRODUCTION CONTROL

962 No treatment of a subject as comprehensive as Graphic Production Control would be complete without calling attention to the pitfalls which must be avoided if success is to be the result of the installation. It might be thought that the author is weakening his position by thus admitting that there are pitfalls, but he trusts he is practical enough to realize that nothing is ever perfect, and that the reader realizes this fully as well, and will readily appreciate a frank discussion of the things which can cause a failure of the plan.

963 The automobile has a brake, the boiler a safety-valve, the engine a governor, in fact, limits are recognized in all things, and the writer will be the last to assert that Graphic Production Control has no catch-traps.

964 In our experience, we have naturally been through some trying times in finding "bugs" and eliminating them; in overcoming opposition; in getting around obstacles; in meeting complex and discouraging situations; and the results of all this are considered important enough to pass along to any fair-minded reader—the other kind, the human "if," wouldn't be interested in the subject of graphics, anyway.

965 The pitfalls will be considered in the form of "don'ts," as follows:

966 *A* Don't Blame the Control Boards if They Show False or Incorrect Information. Control boards are nothing but blocks of wood or pockets of steel, holding strips of paper, to which is posted information by clerks. If the boards show what is not so, then one of two things is to blame—

a Incorrect information supplied to board clerks.

b Inaccuracy of board clerks in posting.

If Steel common is 97 and it is posted as 79 on a broker's board, this does not make the board any the less valuable.

967 *B* Don't Overlook the Importance of Accurate Descriptions of Work. It is very necessary to have accurate and reliable information as to kind of work performed and quantity produced. In posting to the boards, the proper place must be located and the quantity credited in black in one place and charged in green at another. If supporting facts have been incorrectly stated, they will naturally be posted to the wrong place, or the green and black entries will be incorrect, either of which will make for false impressions.

968 *C* Don't Attempt Graphic Production Control Without Accurate Time-keeping Methods. Remember, the charges and credits to boards are in terms of standard hours of work released by material received or accomplished through labor effort. If the time reported by workmen is inaccurate, it will tend to show work further ahead or further behind than it really is. Don't allow workmen to keep their own time, as they are not clerks.

969 *D* Don't Fail so to Organize as to Have Prompt Reports of all Irregular Conditions. The only way to secure results from the installation of the method proposed, is not only to secure the coöperation of the shop personnel, but to get them to depend on the boards for facts as to production details. If machines are idle; if workmen are absent; if material is low; if no tools are on hand; if operator is behind, and the boards fail to indicate these conditions through distinguishing signals, then the shop men will lose confidence in the showing and go back to their old methods of posting themselves regarding conditions.

970 *E* Don't Attempt to Go Very Far with Some of the Shop People Opposed to the Work. A thing is only half sold when there are men in responsible positions who oppose the installation of any new mechanisms. Unless all are convinced of the need and are entirely in favor of the plan, failure is almost certain,—at least, the only thing to expect is a near-success. Too much in the way of getting

results depends upon the coöperation of shop people to risk going too far without their help. Opposition, even if only passive in nature, is dangerous. Steps should therefore be taken to educate a shop personnel as to the merit of the plan before active work is begun.

971 *F* Don't Decide Simply to "Try" the Proposition. A trial indirectly indicates doubt as to eventual success, and there must be no doubts as to the introduction of the methods advocated. Either they appeal to your reason and judgment or they do not. They will secure results or they will not. They will take too long a time or they will not. The installation will cost too much or it will not. Be sure of your ground before starting, but, having decided to go ahead, let nothing stop you until results are yours, as they are bound to be, with the right kind of determination behind the work.

972 *G* Don't Expect the Best Planning Without Having Proper Storeroom Methods, With Knowledge of Correct Balances of Material. If schedules are made on the assumption that materials are available, only to find them not on hand, as shown by the stock records, all board and control work is that much wasted effort, causing confusion, changes in schedules and general dissatisfaction. I cannot spend ten dollars if I have only two dollars. To get ready to make ten pieces and find only two to work on is bad practice, any way you look at it. No production control is possible without material control.

973 *H* Don't Overlook the Importance of Adequate Shop Transportation Facilities. An entry in black at one place means an entry in green at a succeeding operation, and unless shop moving is properly controlled, men will start on work for which no material is on hand, and the boards will be blamed for the false showing.

974 *I* Don't Fail to Have Prompt and Proper Inspection. Whether the black entry covers pieces good or pieces made (good and bad), the graphic record on the boards must show rejections as soon thereafter as is possible. Remember, the board is a picture of all happenings, but if the data posted to it are too long delayed, the picture is not a true one.

975 *J* DON'T MAKE UP YOUR MIND IN FAVOR OF THE METHODS TO-DAY AND START INSTALLATION TO-MORROW. Graphic Production Control is as much an engineering proposition as is the building of an engine. For this reason, there must be a design carefully worked out in order to consider the local conditions met with; it must be put up in the form of specifications with forms and records supporting them; the matter of the organization to handle the methods is most important, and, last but not least, the plan must be fully explained and sold to those who will be influenced by the installation. "Haste makes waste" is true here as everywhere else.

976 *K* DON'T FAIL TO GUARD AGAINST LOSS OF RECORDS DURING PROGRESS OF WORK. Supposing a train dispatcher should lose some records that he relied upon in connection with dispatching his trains? Confusion—perhaps wrecks—would follow. Loss of records in production work is just as serious, as it means delays, annoyance, rearrangement in schedules and failure to carry out plans made.

977 *L* DON'T MAKE CHANGES IN THE METHODS WITHOUT A THOROUGH INVESTIGATION. Any change in methods at any single point is bound to have its effects on the plan as a whole. A clerk may have a bright idea which may be excellent and save time—*for him*—but which may "raise Cain" with other features of the work, and in the end cause much more lost time than the gain. Graphic Production Control is as much made up of component parts as the engine, and no management should make *any* changes without putting the matter up to a committee representing the different interests affected.

978 *M* DON'T BE ALARMED AT THE CLERICAL HELP NECESSARY TO OPERATE THE PLAN. Graphic Production Control centralizes the work of many people in different departments. It takes some from this clerk, that foreman and the other executives and places it all in one department. In reality, little extra work is done, but it is done better and more promptly. If a clerk can do some of the things a foreman has been doing, you are getting the work done just as efficiently and at less cost, besides making a better man out of your foreman by enabling him to devote more of his time

to the larger phases of his work. In many cases enough clerical work has been found carried on by clerks, foremen and executives to run a Control Department efficiently and successfully by simply rearranging the work and providing the clerical assistance necessary in one place.

979 *N* Don't be Concerned at the Thought of Unit Time Cards. The very purpose of Graphic Production Control is to supply current information—currently. The unit time card (one job to a card each day) makes possible prompt recording of work done, where a time card covering all the jobs for a day would mean delays in posting information to the boards and greater confusion in compiling information from the cards.

980 *O* Don't Fail to Supply the Proper Messenger and Telephone Facilities for Dispatch and Control Stations. What would stock quotations amount to without the excellent messenger, telephone and wire service which go with the stock exchange trading? If you want your control mechanism to be up to the minute and efficient, don't fail to provide adequate messenger and telephone service; and if the installation is a large one, the telautograph can be used to decided advantage, especially if on the desks of executives responsible for plant operations.

981 *P* Don't Fail to Give the Proper Consideration to Standard Hourly Production. In one sense, standard hourly productions are the heart of the work of Graphic Production Control. They not only constitute the ideals to aim at, but directly influence the black and green entries and the readings as regards whether work is ahead or behind. Imagine finding a job ahead and complimenting the worker, only to discover that the S. H. P. is too easy! What is still worse is to find an operation behind, call the worker down and then find the schedule impossible of attainment. Further, S. H. P.'s are the basis of good estimating and efficiency determination, and sufficient attention should therefore be given to them to keep them up to date, new ones being created and changes made where necessary. This work is a most important part of the installation.

982 *Q* Don't Get Discouraged or Allow Others to Get Discouraged. During the period of installation, new

and complex conditions are met with which were not covered by the plan as originally outlined. The best brains are not infallible, and the only consistent advice is to meet each issue as it comes up, find a solution, then go ahead until the next one is met and repeat the procedure. Remember, success comes to him who keeps his teeth in the longest. That is why the bull-dog doesn't bark—he is too busy hanging on.

983 *R* Don't Allow any Part of the Work to Fall Behind. Even after the production work is done, which must be right up to the minute at all times, the speed from this point must be just as great. Production Control records are used for payroll purposes, bonus payments, accounting, cost compilations, preparation of statistics and the like, and any delays only tend to discredit the entire plan in the minds of those who use the data supplied by the control mechanism.

984 *S* Don't Look Upon Your Graphic Production Control Installation as an Expense, but as an Investment. You may buy a machine which you consider as an investment and include in the company assets. Look upon your production control mechanism in the same manner even if you cannot treat the installation in the same manner as the machine on the books of the company. If you view the matter from the standpoint of an expense, you will not have the patience in getting results as you would have in the case of the machine. If you will look upon the work as an investment, you will act accordingly, and your returns will be just as sure as in the case of the machine.

985 *T* Don't Look for Immediate Results, as They Will Not be Forthcoming. To install Graphic Production Control requires time, patience and the exercise of considerable tact. There is the period of design, of preparing specifications, of getting the devices ready, of educating those influenced, of installation and of getting the mechanism working properly. You have that variable factor, the human element, to deal with constantly. Results will not be apparent at first, complications will arise, personnel will want to go back to the old ways which have become habits with them. Remember that during the installation it is in-

directly bringing about better organization, standardization, costing and supplying information never before secured, and you can well afford to wait for the results which are bound to come. This does not mean that you must sit idly by and let the thing run itself, for it won't do it—it needs a strong guiding hand. There is a mighty big difference between impatient lack of direction and patient guidance; between destructive criticism and constant kicking and constructive advice and help.

986 *U* Don't Overlook the Importance of Graphic Production Control to Your Business. You are in business to produce goods. To produce efficiently you must control efficiently, the one being in direct proportion to the other. Graphic Production Control therefore has a direct bearing on your profit and loss account. Further, it is not only the basis for manipulation of production forces,—labor, material, equipment and product,—but it is also the basis of your cost, accounting, financial and statistical records and policies and therefore has a direct bearing on the management of your business. "Graphical Management" is as superior to systematized management as systematized management was to the "unsystematic management" of the old days.

987 *V* Don't Overlook the Importance of Information as to the Proper Flow of Product and Sequence of Work. Of fundamental importance in any scheme of Graphic Production Control is accurate knowledge of the flow of work through the plant; of the logical relation and importance of groups and parts; of sequence of the operations of parts. In planning and scheduling to boards and dispatching through stations, the basis is entirely that of records as to the above. If they are inaccurate, work will be routed to the wrong places, or right places will be designated but the work will be in the wrong sequence, or last things will come first and first things last, all of which spell serious loss of time, endless confusion and consequently irritation and general "cussing" of the whole control installation.

988 *W* Don't Fail to Secure the Interest and Cooperation of Your Workmen. As will be seen from the

next chapter, on the Economic Aspects of Graphic Production Control, Labor should be just as much interested in the subject as Capital, as the elimination of inefficiency is as much the responsibility of one as of the other. Make them see this, if possible, and results will be that much greater. If they think the methods are being forced on them, they will resent it and make little, if any, efforts to coöperate. Their assistance is both necessary and profitable to them as well as to you.

989 *X* Don't Fail to Train Your Control Department Force and Arrange for Understudies. Remember that no chain is stronger than its weakest link. So with this work. If you have incapable help, improperly trained, with no understudies, you will have constant trouble, which will spell loss of production, seriously affecting your pocketbook. Provide efficient clerical help, have educational meetings instructing them as to their work, and have understudies ready when help is sick or leaves or is promoted, and you will have no cause for alarm. You place a high-grade operator at a high-grade machine. You should do no less with your control machinery.

990 *Y* Don't Have Anything Else but a Successful Installation. If you suddenly find that your installation is a failure, consult a looking-glass, for the reason for your failure will be—*you*. The work can be successful because it has been and is securing results, in a variety of lines, in cases of simple work and where there are extreme complications. If you go at things in the right way and take time to design, build and install, following the instructions in this and other chapters, there should be no failure. If there is—well, don't play the game called "passing the buck," but acknowledge your part of it and *start again. You'll win.*

991 The above sums up the principal "don'ts." Others could be given, but this list, if lived up to, is sufficiently broad to cover the ground in such a way as to make for a successful installation.

CHAPTER XXVIII

ECONOMIC ASPECTS OF GRAPHIC PRODUCTION CONTROL

992 In an editorial on "Work," the *New York Tribune* said:

"As war-time inflation sent wages and prices spiralling upward, the advantage often rested with the worker. His money wage advanced faster than prices, so that, temporarily, a given amount of work gave him command over more goods than a like amount of work commanded when wages and prices were, relatively speaking, in a state of peaceful flatness. He was, therefore, in a position to choose between saving for the future or cutting down the number of hours of labor. Often he elected to take leisure in lieu of wages. The average working week was cut to a point lower than it ever had been before.

"Leisure is sweet and desirable. But too much of it suddenly may wreck the economic order. All material things are produced by labor. People cannot consume what they do not produce. Neither can they consume all they produce without depriving posterity of its opportunities. The world is not attending to the future. It is living in the present. It must get capital ahead or sink. The only way to accumulate capital is to work. But there is an increasing demand for still shorter hours, on the theory that 'the less work a man does the more work there is for others.' The fallacy lies in the assumption that there is not enough work to go all around. The fact is, work as hard as it may, the world will be unable for years to make good the destruction of

war and the loss incident to deferring work. The acute shortage of housing, here and abroad, illustrates a condition that extends to scores of industries. The National Association of Manufacturers views the outlook so seriously that it has undertaken a nation-wide campaign to urge labor to speed up output to the limit.''

993 As this chapter is being written, the whole country is agitating investigations of the food situation, prices and price-making, profiteering and other factors having a bearing on the common enemy—the High Cost of Living. The general attitude is that unless prices are reduced, wages will have to be still further increased to keep pace with the ever increasing tendency of prices.

994 Up to this time we have had no intelligent recommendation as regards *how* prices are to be reduced. The railroad brotherhoods now come along with the demand for Federal control of the railroads, for profit-sharing, for participation in the management of the roads, promising, as a result, that the move will be the first and most important step toward lowering the cost of living.

995 Let us analyze the situation to ascertain the merits of this recommendation. We have been living, and are now living, in an industrial age based on a theory which can be expressed as ''more wages and fewer hours.'' Despite our rapid strides industrially, we have viewed with ever increasing alarm the vicious cycle of increased wages, to increased costs of products, to increased prices, and so on around the circle, until the prediction is ventured that unless there is a change of some kind, this country is due to receive a rude jolt in the not far distant future, in the form of one of the worst panics in its history, *and there won't be any question at all where prices will be then.*

996 The British Board of Trade announced that for the first twenty weeks of 1919, with wages the highest ever known, the production of coal was 240,000,000 tons as against 287,000,000 in the last pre-war year, *with the number of miners the same in both years.* The Government, in announcing an increase in price of coal to consumers, made

this illuminating statement: "because of increased wages, shorter hours for the miner, and decreased production per workman."

997 It will be generally admitted that "more wages for fewer hours" *means less production at greater cost.* If we add to this a decreased equivalency per hour worked, the situation is that much worse and the cost that much higher per unit produced. This is an economic truth which will withstand any amount of argument. Therefore the basic theory above mentioned is not only economically false, but dangerous to the industrial and commercial success of this great country of ours, *and should be fought to a finish.*

998 The unionists are at last beginning to see this. The brotherhoods' representative says:

> "We realize that in the strife for wage increases we cannot win any permanent victory. It is not money, but value, which counts."

—and value can only be taken to mean equivalency.

999 We cannot stop producing, and still have production. The pie cannot be in the stomach and on the shelf at the same time. If industry produces less at greater costs, prices must increase, and as prices increase, *demand must decrease.* A decreased demand can only spell restricted production, impaired credits, unemployment and general inactivity. The chief sufferers? The workers, who themselves are the chief exponents of this false economic theory of "less hours, more wages" so as to make "more work for more people."

1000 Imagine what would happen if one plant worked ten hours per day and another worked two hours per day, the workers in both plants receiving the same wages! Which would get the business? Now consider one country whose industry operates ten hours per day, with another operating two hours per day, with the workers of the ten-hour-per-day country receiving *less* wages than the workers of the two-hour-per-day country. *Where would the business go?* In other words, the more we continue this false theory mentioned, the worse off we are going to be from an economic standpoint; and as the basis of industry,

whether national or international, is competition, it can be seen that we are slowly but surely riding to a fall.

1001 *And what do we get as solutions?* The cry for investigations and Federal control. Investigations will avail little beyond determining that costs of production are too high, which any well-informed industrial engineer now knows to be the case, to his sorrow as a good American citizen. Federal control means only a shifting of responsibility, *and in itself cannot reduce prices;* in fact, the chances are that the move will still further increase prices.

1002 It is generally conceded that wages cannot come down until the cost of living comes down, nor can the cost of living come down until the basis of cost—wages—comes down. Hence we find ourselves between the devil and the deep sea, and the only consolation we are given are recommendations for investigations and federalization.

The fact of the matter is, *that when MORE is produced, there will be MORE to divide, and wages will buy MORE without raising prices.*

1003 The real causes of the vicious cycle of ever increasing prices are:

A On the part of *Capital,* idleness in the use of materials, plant and equipment—*waste in money.*

B On the part of *Labor,* retarding production through demanding (and getting) reduced hours and more wages, and in some cases restricting or retarding productions per hour—*waste in time.*

1004 Eliminate one or the other, or both, of these, and there will be a noticeable and rapid improvement, the result of which will be—*Low Cost of Living;* and we can have prosperity, employment and an economically sound industrial basis, which will serve us to advantage in international competition.

1005 I have spoken of the real cause of the vicious cycle. I now propose the solution in the form, not of a lot of investigations, which would not get us very far, nor of federalization, which is but a change from one plan to another, *but greater efficiency on the part of both Capital and Labor.*

1006 This efficiency can come only through *economic*

production, by which I mean quantity production, of the right quality, at the lowest possible cost, through the elimination of idleness in money and in time. In this both Capital and Labor have a part. Both are to blame for the conditions now existing, and neither side should try to unload all the blame upon the shoulders of the other.

1007 Capital must agree to study this idleness factor as never before. Labor must be willing to give proper equivalency and to adopt labor-saving machinery and methods. No relief of a permanent nature may be expected *until both agree to this.*

1008 As has been pointed out before, to secure production, *it must first be controlled;* and it has been this matter of controlling production to which the author and his able associates have devoted so many years of close study, resulting in the development of Graphic Production Control, herein described.

1009 No, it is not a case of over-enthusiasm, optimistic as I am over the possibilities in the methods described. It is a case of firm conviction, born of study and actual contact with industrial ills and their elimination.

1010 The answer to our great problem of efficient living is *production;* and if, through our control mechanisms, we can spot idleness in the use of money on the part of Capital (material, plant and equipment), we are only a step from betterment. If we can determine equivalency and watch its attainment or lack of it, we are on the road to improvement in this respect. It all gets back to *time,* whether wasted by Capital or dissipated by Labor; and the principal function of Graphic Production Control is, through visualization, to turn the spot-light on these failures.

1011 We set a standard hourly production. This determines what an article should cost. If it costs more, one or the other, or both, are to blame, and we want to know who and why. Graphic Production Control shows this in unmistakable fashion.

1012 As standard hourly productions are increased in all lines, prices will come down in proportion,—an economic truth which cannot be argued against, as competition can be trusted to take care of the matter of excessive profits.

Therefore, the better we determine and watch these equivalents, the more prices will be reduced; and if Graphic Production Control can do this, or assist in doing it, then there is an economic value about it which entitles it to serious consideration by both Capital and Labor.

1013 Visualization of idleness and failure to produce at maximum is possible through Graphic Production Control, from which increased production is but a step if both sides are sincere in their desire to stop idleness and waste and work for efficiency.

1014 Because we can have more riches only by producing more riches; because prices can come down only as we increase productions; because we can produce that most efficiently which we can control most efficiently, our plea is that a consistent study be made of graphic methods of controlling production, which, while directly securing results in increasing production, indirectly lead to organization, standardization and costs.

1015 Graphic Production Control is sound in principle, is practical in its working in industry, has progressed beyond the experimental stage, is economically necessary, and is therefore recommended to the thoughtful consideration of industrial leaders, whether in the ranks of Capital or in those of Labor.

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